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SITE-SPECIFIC TECHNICAL REPORT (A003)

for

SHORT-TERM PILOT TEST FOR THE BIOSLURPING FIELD INITIATIVE AT
HICKAM AFB, HONOLULU, HAWAII

by

J.A. Kittel, M.C. Place, A. Leeson, J.T. Eastep, G.L. Headington, and E. Drescher

for

MR. PATRICK HAAS
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
TECHNOLOGY TRANSFER DIVISION
BROOKS AFB, TEXAS 78235

May 31, 1995

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

This report summarizes the field activities conducted at Area H, Hickam Air Force Base (AFB), Hawaii, for a short-term field pilot test that compared vacuum-enhanced free-product recovery (bioslurping) to traditional free-product recovery techniques to remove light, nonaqueous-phase liquid (LNAPL) from subsurface soils and aquifers. The field testing at Hickam AFB is part of the Bioslurping Field Initiative, which is funded and managed by the U.S. Air Force Center for Environmental Excellence (AFCEE). The AFCEE Bioslurper Initiative is a multisite program designed to evaluate the efficiency of bioslurping technology for (1) recovery of LNAPL from groundwater and the capillary fringe and (2) enhancing natural in situ biodegradation of petroleum contaminants in the vadose zone via bioventing.

The main objective of the Bioslurping Field Initiative is to develop procedures for evaluating the potential for recovering free-phase LNAPL present at petroleum-contaminated sites. The overall study is designed to evaluate bioslurping and identify site parameters that are reliable predictors of bioslurping performance. To measure LNAPL recovery in a wide variety of in situ conditions, tests are being performed at many sites. The test at Hickam AFB is one of at least 35 similar field tests to be conducted at various locations throughout the United States and its possessions.

The intent of field testing is to collect data to support determination of the predictability of LNAPL recovery and to evaluate the applicability, cost, and performance of the bioslurping technology for removal of free product and remediation of the contaminated area. The on-site testing is structured to allow direct comparison of the LNAPL recovery achieved by bioslurping with the performance of more conventional LNAPL recovery technologies. The test method included an initial evaluation of site variables that could affect LNAPL recovery efficiency, conduct of field treatability studies to determine bioventing potential, and LNAPL recovery testing. Site characterization activities included soil sampling, slug testing, and baildown testing. Field treatabilities studies included an in situ respiration test and a soil gas permeability test. The three technologies used at Hickam AFB to recover the free LNAPL floating on the water table were skimmer pumping, bioslurping, and drawdown pumping.

After site characterization activities, pilot tests for the skimmer pumping, bioslurping, and drawdown pumping were conducted. The bioslurper system was installed in an existing extraction well, monitoring well GT-H9. The pilot test sequence was as follows: two days in the skimmer mode (no vacuum); five hours in the bioslurper mode; and five hours in the drawdown mode (groundwater

depression mode). Tests in the bioslurper and the drawdown mode were shorter than normal because carbon canisters used to remove the off-gas petroleum compounds were depleted and total petroleum hydrocarbon (TPH) concentrations would have exceeded the regulatory limit if the tests had not been terminated. Measurements of the extracted soil gas composition, free product thickness, and groundwater level were taken throughout the testing. The volumes of LNAPL recovered and groundwater extracted were quantified over time.

Each of the three recovery configurations tested was able to recover LNAPL from monitoring well GT-H9. Unfortunately, the bioslurping configuration could not be properly evaluated due to improperly screened and/or sealed wells. At this site, there are relatively sandy soils to a depth of approximately 5 ft, then a lithology change to relatively impermeable volcanic rock with groundwater at approximately 15 ft. With part of the screened interval in a much more permeable zone, during bioslurping the majority of vapor flow occurred in this region, reducing the effective vacuum at the wellhead. Based on results from the baildown testing, this site is likely to be an excellent candidate for bioslurping; however, new wells would have to be installed with the entire screened interval below the permeable zone.

Due to the problem with the screened interval of the monitoring well, results were inconclusive from permeability testing and monitoring of oxygen concentrations during bioslurping. All monitoring points were screened within the volcanic rock; however, because the majority of flow was within the upper permeable zone, neither significant oxygen increases or pressure changes were detected at the monitoring points. Results from in situ respiration testing did demonstrate relatively high microbial activity with an average biodegradation rate of 13 mg/kg/day or approximately 4,800 mg/kg/year.

Implementation of bioslurping at Area H, Hickam AFB likely would facilitate enhanced free product recovery and simultaneous in situ biodegradation of hydrocarbons in the vadose zone via bioventing given properly screened wells. The feasibility of implementing bioslurping would depend on long-term requirements for vapor treatment and disposition requirements for extracted groundwater at the site.

DRAFT
SITE-SPECIFIC TECHNICAL REPORT

for

SHORT-TERM PILOT TEST FOR THE BIOSLURPING FIELD INITIATIVE AT HICKAM AFB, HONOLULU, HAWAII

May 31, 1995

1.0 INTRODUCTION

This report describes activities performed and data collected during a field test of vacuum-enhanced pumping (bioslurping) at Area H, Hickam Air Force Base (AFB), Hawaii. The field testing at Hickam AFB is part of the Bioslurping Field Initiative, which is funded and managed by the U.S. Air Force Center for Environmental Excellence (AFCEE). The AFCEE Bioslurper Initiative is a multisite program designed to evaluate the efficacy of bioslurping technology for (1) recovery of light, nonaqueous-phase liquid (LNAPL) from groundwater and the capillary fringe, and (2) enhancement of natural in situ biodegradation of petroleum contaminants in the vadose zone via bioventing.

1.1 Objectives

The main objective of the Bioslurping Field Initiative is to develop procedures for evaluating the potential for recovering free-phase LNAPL present at petroleum-contaminated sites. The overall study is designed to evaluate bioslurping and to identify site parameters that are reliable predictors of bioslurping performance. To measure LNAPL recovery in a wide variety of in situ conditions, tests are being performed at many sites. The test at Hickam AFB is one of at least 35 similar field tests to be conducted at various locations throughout the United States and its possessions. Aspects of the testing program that apply to all sites are described in the *Test Plan and Technical Protocol for Bioslurping* (Battelle, 1995). Test provisions specific to activities at Hickam AFB are described in the site-specific Test Plan provided in Appendix A.

The purpose of the field testing was to collect data to support determination of the predictability of LNAPL recovery and to evaluate the applicability, cost, and performance of the bioslurping technology for removal of free product and remediation of the contaminated area. The on-site testing was structured to allow direct comparison of LNAPL recovery achieved by bioslurping

with the performance of more conventional LNAPL recovery technologies. The test method included an initial evaluation of site variables followed by LNAPL recovery testing. The three technologies used at Hickam AFB to recover free LNAPL floating on the water table were skimmer pumping, bioslurping, and drawdown pumping. The specific test objectives, methods, and results for the Hickam AFB test program are discussed in the following sections.

1.2 Testing Approach

Initial site characterization activities were conducted to evaluate site variables that could affect LNAPL recovery efficiency and to determine the bioventing potential of the site. These activities included soil sampling to determine physical/chemical site characteristics, slug tests to evaluate the hydrogeologic conditions near the test well, in situ respiration testing to evaluate site microbial activity, and baildown tests to evaluate the mobility of LNAPL in the site monitoring well.

Following the site characterization activities, the actual pilot tests for the skimmer pumping, bioslurping, and drawdown pumping were conducted. The bioslurper system was installed so that an existing groundwater monitoring well, GT-H9, could be used for the testing. The LNAPL recovery testing was conducted in the following sequence: two days in the skimmer mode (no vacuum); five hours in the bioslurper mode; and five hours in the drawdown mode (groundwater depression mode). The tests were performed in sequence with only small delays after each test so the system could be reconfigured for the next test. Tests in the bioslurper and the drawdown mode were shorter than normal because carbon canisters used to remove the off-gas petroleum compounds were depleted and total petroleum hydrocarbon (TPH) concentrations would have exceeded the regulatory limit if the tests had not been terminated. Measurements of the extracted soil gas composition, free product thickness, and groundwater level were made throughout the testing. The volume of LNAPL recovered and groundwater extracted were quantified over time. A soil gas permeability test was conducted during the bioslurper test.

2.0 SITE DESCRIPTION

A schematic diagram of Area H is shown in Figure 1. Site personnel indicated that former underground storage tanks (USTs) near the site were the most likely sources of contamination in the

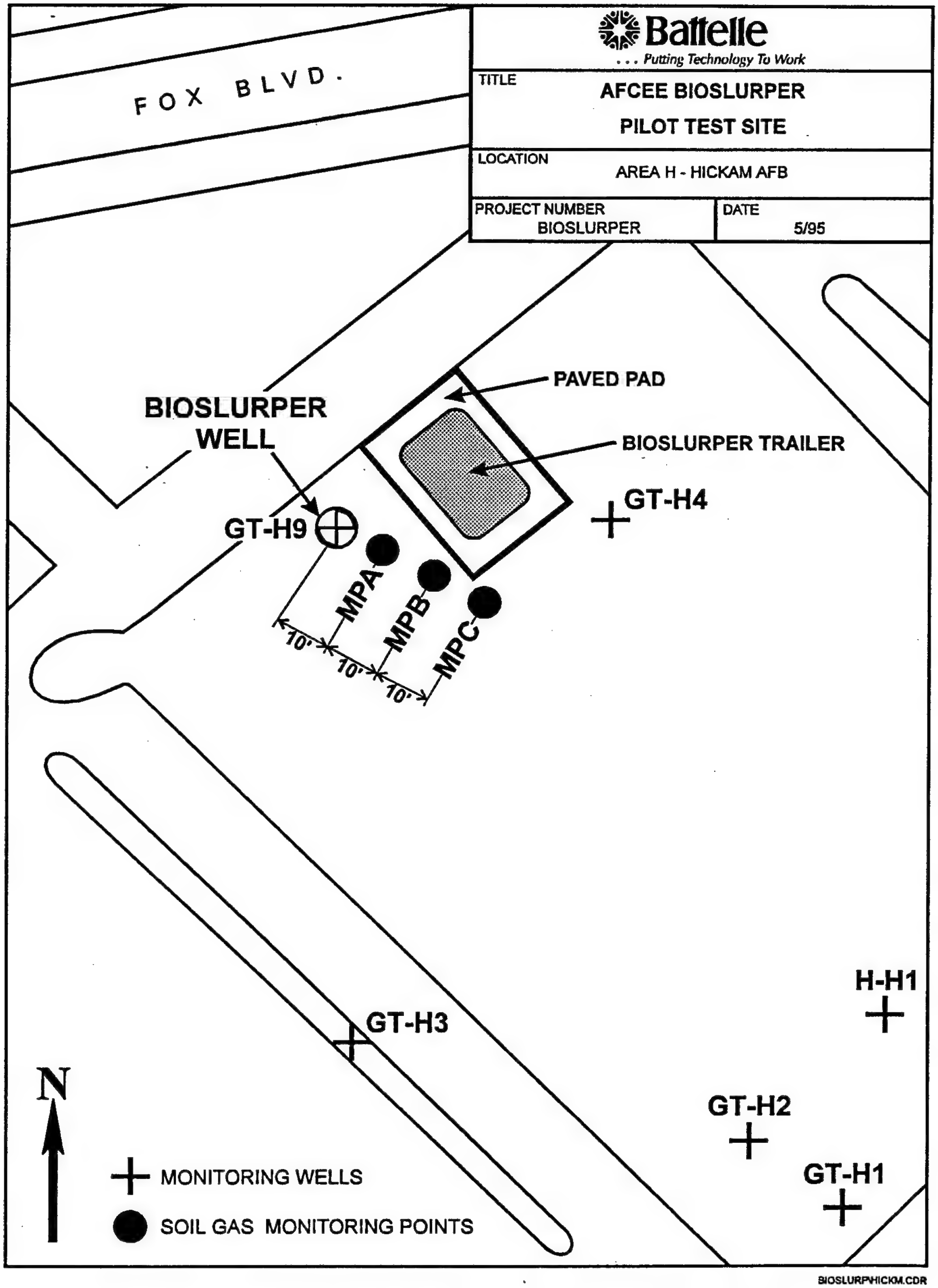

Figure 1. Schematic Diagram Showing Locations of Bioslurper Well, Soil Gas Monitoring Points, and Monitoring Wells at Area H, Hickam AFB, HI

area. The existing fuel plume that is contaminating the soils and groundwater in this area is aviation gasoline. Previous characterization of the soil and groundwater have shown that benzene concentrations ranged from 0.010 to 0.020 mg/L and TPH ranged from 6.0 to 7.0 mg/L.

It appears that the fuel contamination at this site is localized in a 4-ft-thick layer at the water table surface with some contamination of the soils in the vadose zone. The contamination of the soils in the vadose zone is likely the result of smearing of the free product during tidal fluctuations. The free product detected at monitoring well GT-H9 is likely the result of lateral migration of the fuel along the water table surface as opposed to a top-down surface spill.

3.0 PILOT TEST METHODS

This section documents the initial conditions at the test site and describes the test equipment and methods used for the short-term pilot test at Area H, Hickam AFB.

3.1 Well Construction Details

Monitoring well GT-H9 was selected for installation of the test equipment because it had the greatest thickness of free product at the test site and appeared to be near the center of the contaminant plume. Construction details for this well were not available; however, from visual inspection it was apparent that the well was constructed of 4-inch-diameter, schedule 40 polyvinylchloride (PVC) and the screened interval appeared to begin at approximately 5 ft. The total depth of the well was measured at 24.3 ft. It is unknown whether the well was properly sealed. A schematic diagram illustrating lithology and known well construction details is shown in Figure 2.

3.2 Initial LNAPL/Groundwater Measurements and Baildown Testing

Initial LNAPL thickness measurements and depth to groundwater were measured using an oil/water interface probe (ORS Model #1068013). The initial fuel thickness in monitoring well GT-H9 is presented in Table 1. LNAPL was removed from the well with a Teflon™ bailer until the LNAPL thickness could no longer be reduced. The rate of increase in the thickness of the floating LNAPL layer in the well was monitored for 7.25 hours using the oil/water interface probe.

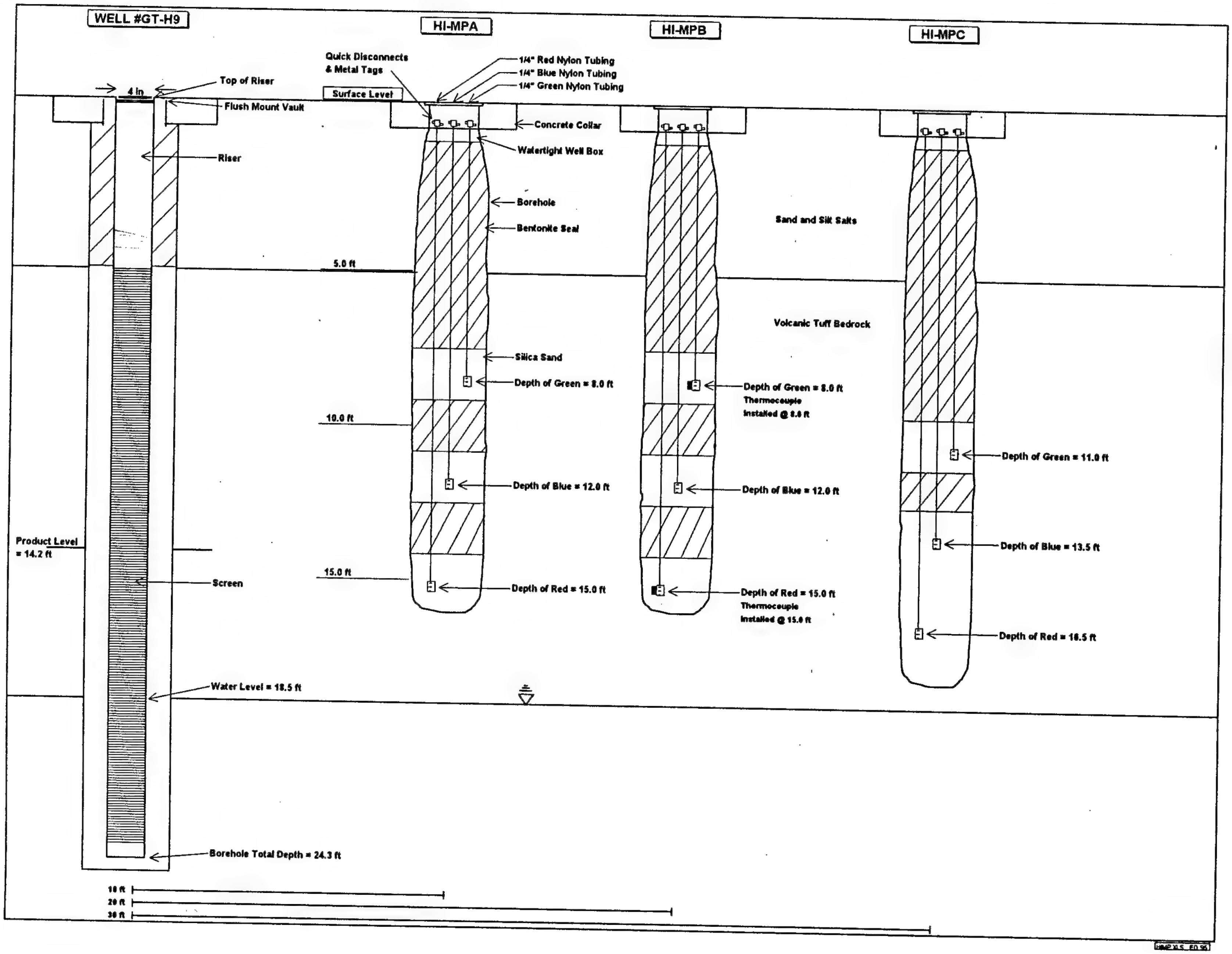

Figure 2. Schematic Diagram Showing Site Lithology and Construction Details for the Extraction Well and Monitoring Points

Table 1. Initial Conditions in Monitoring Well GT-H9 Prior to Fuel Recovery Tests

Test	Test Start Date	Depth to LNAPL (ft)	Depth to Groundwater (ft)	LNAPL Thickness (ft)
Initial Conditions	NA	14.18	18.51	4.33
Baildown Test	March 7, 1995	14.61	18.59	3.98
Skimmer Pump Test	March 10, 1995	14.44	18.33	3.89
Bioslurper Test	March 12,1995	15.55	15.80	0.25
Drawdown Pump Test	March 14, 1995	NA	15.40	NA

NA = Not applicable.

3.3 Monitoring Point and Thermocouple Installation

On March 7 through 9, 1995, three monitoring points (MPs) were installed in the area of monitoring well GT-H9 and were labeled HI-MPA, HI-MPB, and HI-MPC. Figure 2 illustrates a cross section of the monitoring points and shows the site lithology and construction detail.

Monitoring points consisted of sets of ¼-inch tubing with a 1-inch-diameter, 6-inch long screened area. The screened length was positioned at the appropriate depth, and then the annular space corresponding to the screened length was filled with silica sand. The interval between the screened lengths was filled with bentonite clay chips, as was the space from the top of the shallowest screened length to the ground surface. After placement, the bentonite clay was hydrated to expand the chips and provide a seal. The monitoring points were installed at depths as follows:

- Monitoring point HI-MPA was installed 10 ft south of monitoring well GT-H9 in a 6-inch-diameter borehole to a depth of 18 ft. Screened lengths were placed at three depths: 8.0, 12.0, and 15.0 ft.

- Monitoring point HI-MPB was installed 20 ft south of monitoring well GT-H9 in a 6-inch-diameter borehole to a depth of 18 ft. Screened lengths were placed at three depths: 8.0, 12.0, and 15.0 ft.

- Monitoring point HI-MPC was installed 30 ft south of monitoring well GT-H9 in a 6-inch-diameter borehole to a depth of 18 ft. Screened lengths were placed at three depths: 11.0, 13.5, and 16.5 ft.

Type K thermocouples were installed in monitoring point HI-MPB at depths of 8.0 and 15.0 ft.

After installation of the monitoring points, initial soil gas measurements were taken with a GasTechtor portable O_2/CO_2 meter and a GasTech Trace-Techtor portable hydrocarbon vapor meter. The initial soil gas compositions are shown in Table 2.

3.4 Soil Sampling and Analyses

One soil sample was collected during the installation of monitoring point HI-MPA at a depth of 13 to 13.5 ft using a split-spoon sampler with brass sleeves driven down the center of the hollow stem auger. Attempts were made to collect additional samples using a split-spoon sampler, but due to the lithology at the site, these attempts were unsuccessful. Additional soil samples were collected from drill cuttings from drilling of monitoring point HI-MPB and HI-MPC for quantification of contamination in the disposal drums at the request of the base. The samples were labeled as follows: MPA-13.0-13.5, D-1, and D-2. The samples were placed in insulated coolers, chain of custody records and shipping papers were completed, and the samples were sent to the Environmental Laboratory of the Pacific, Honolulu, Hawaii. Each of the samples were analyzed for benzene, toluene, ethylbenzene, and total xylenes (BTEX); polycyclic aromatic hydrocarbons (PAHs) (acenaphthene, benzo(a)pyrene, fluoranthene, and naphthalene); metals (cadmium, chromium, and lead); and TPH. A sieve analysis also was performed on sample MPA-13-13.5. Analytical reports for these analyses are provided in Appendix B.

3.5 LNAPL Recovery Testing

3.5.1 System Setup

The bioslurping pilot test system is a trailer-mounted mobile unit. The vacuum pump, oil/water separator, and required support equipment were transported to Hawaii via air cargo. A trailer was purchased in Hawaii to move the system around the site. The trailer was located near monitoring well GT-H9, the well cap was removed, a coupling and tee were attached to the top of the well, and the dip tube was lowered into the well. The dip tube was attached to the vacuum pump. Different configurations of the tee and placement depth of the dip tube allow simulation of skimmer

Table 2. Initial Soil Gas Compositions at Area H, Hickam AFB

Monitoring Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppmv)
HI-MPA	8.0	18.5	1.0	130
	12.0	15.0	0.5	12,400
	15.0	14.0	0.7	37,000
HI-MPB	8.0	13.5	4.6	90
	12.0	16.0	1.8	860
	15.0	2.5	7.8	>100,000
HI-MPC	11.0	4.8	2.0	10,800
	13.5	0	0.3	>100,000
	16.5	NA	NA	NA

NA = Not available. Sample could not be collected because monitoring point was located below the water table.

pumping, operation in bioslurping mode, or simulation of drawdown pumping as described in Sections 3.5.2, 3.5.3, and 3.5.4, respectively.

At Hickam AFB, extracted groundwater could be discharged directly to the base sanitary sewer system. The extracted water was collected in a 250-gallon tank and transported approximately 0.25 mile to the nearest sanitary sewer drain. High concentrations of petroleum compounds were expected in the soil gas; therefore, a carbon filtration system was incorporated into the system to prevent the release of these compounds to the atmosphere.

A brief system startup test was performed prior to LNAPL recovery testing to ensure that all system components were working properly. The system checklist is shown in Appendix C. All site data and field testing information were recorded in a field notebook and then transcribed onto the pilot test data sheet shown in Appendix D.

3.5.2 Skimmer Pump Test

On March 10, 1995 the skimmer pump test was started. First, the oil/water interface was measured with the oil/water interface probe. The initial fuel thickness prior to the skimmer test is shown in Table 1.

The pump used for all pump tests was an Atlantic Fluidics Model A20, 3-hp liquid ring pump. A schematic diagram showing the configuration of the well and slurper tube for the skimmer pump test is shown in Figure 3. For the test, the extraction tube was set approximately in the middle of the free-product layer anticipating tidal fluctuations in the water table and rebounding of the water table when the free product was removed. The wellhead was open to the atmosphere through a PVC connecting tee. Before the start of the test, the liquid ring pump and the oil/water separator were primed with known amounts of groundwater to ensure that any LNAPL or groundwater entering the system could be quantified. The flow totalizers for the LNAPL and aqueous effluent were zeroed, and then the liquid ring pump was started to begin the skimmer test. The test was operated continuously for 46 hours. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the skimmer pump test. The data collected for this test are summarized in Appendix D.

3.5.3 Bioslurper Pump Test

Upon completion of the skimmer pump test, preparations were made to begin the bioslurper pump test. Table 1 shows the initial free product thickness prior to the bioslurper pump test. Again, the oil/water interface in monitoring well GT-H9 was measured first. The extraction tube was placed 0.2 ft below the LNAPL/groundwater interface because the water table was near a tidal high. However, in contrast to the skimmer pump test, the PVC connecting tee was removed, sealing the wellhead and allowing the vacuum pump to establish a vacuum in the well. A pressure gauge was installed at the wellhead to measure the vacuum inside the extraction well. The configuration of the well and slurper tube for the vacuum-enhanced pump test is shown in Figure 4.

For this test, all product and groundwater flow totalizers were zeroed and reset so that the groundwater extraction and LNAPL recovery rates could be quantified accurately. Then the liquid ring pump was started to begin the bioslurper pump test. The short-term bioslurper test was begun approximately 4.5 hours after completion of the skimmer test. The test was operated continuously for 5.5 hours (approximately 0.23 day). The test was prematurely terminated because carbon canisters used to remove the petroleum compounds from the off-gas were depleted and TPH concentrations in the vapor emissions would have exceeded the regulatory limit if the system was not shut down. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the bioslurper pump test. The data collected for this test are summarized in Appendix D.

3.5.4 Drawdown Pump Test

After the 5 hours of testing in the bioslurper pump mode, the test was halted and preparations were made for the drawdown pump test. The PVC connecting tee was reinstalled on the wellhead so that the well was again open to the atmosphere. The depth to the oil/water interface was measured, and the extraction tube was placed so that the tip of the tube was 1.8 ft below the measured level of the oil/water interface at the beginning of the test. This tube placement creates a cone of groundwater depression around the extraction well to induce LNAPL flow for the drawdown pumping test. A diagram showing the general configuration of the drawdown pump test is depicted in Figure 5.

All LNAPL and groundwater flow totalizers were reset after the bioslurping test and initial measurements were made to determine the drawdown pump test initial conditions. Initial free product

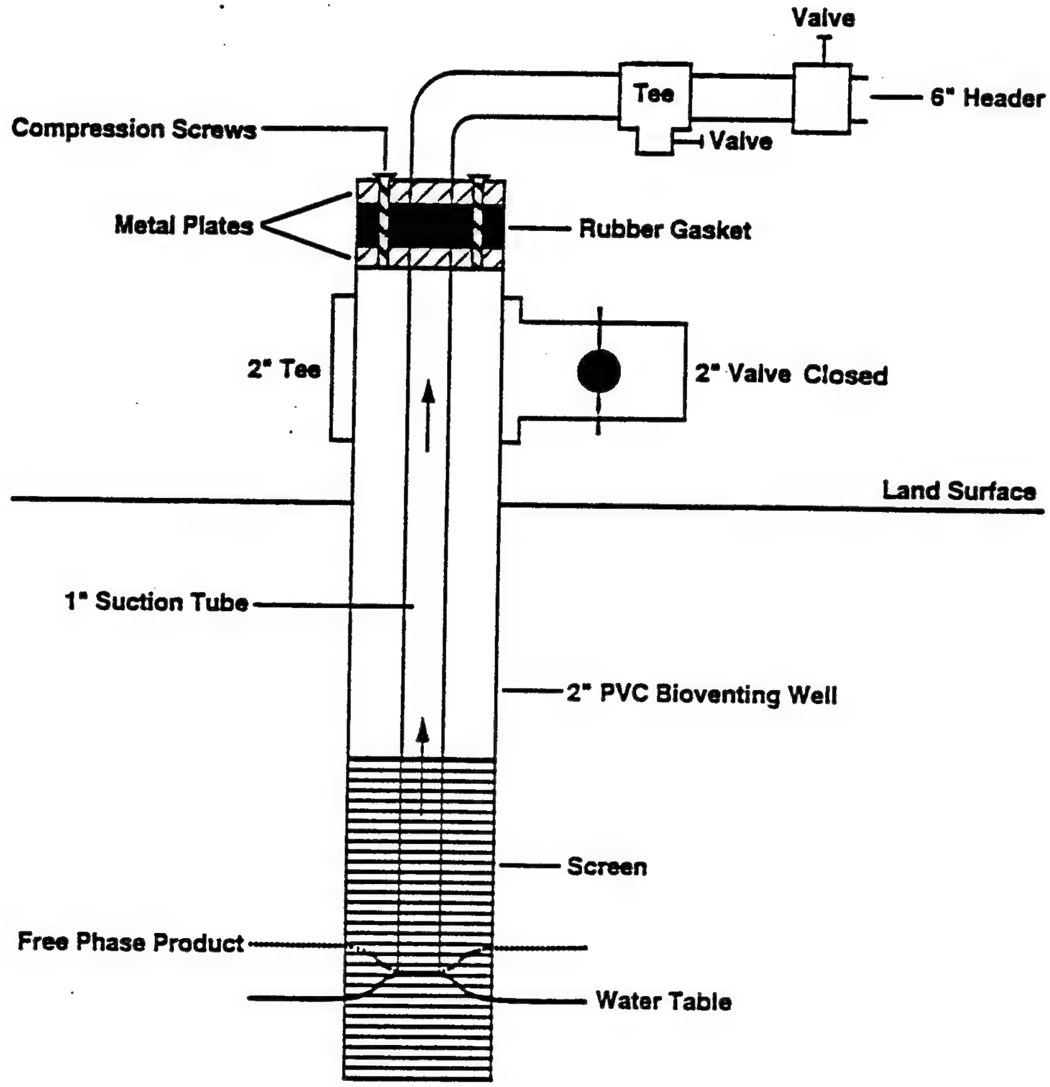

Figure 4. Slurper Tube Placement for the Bioslurper Test

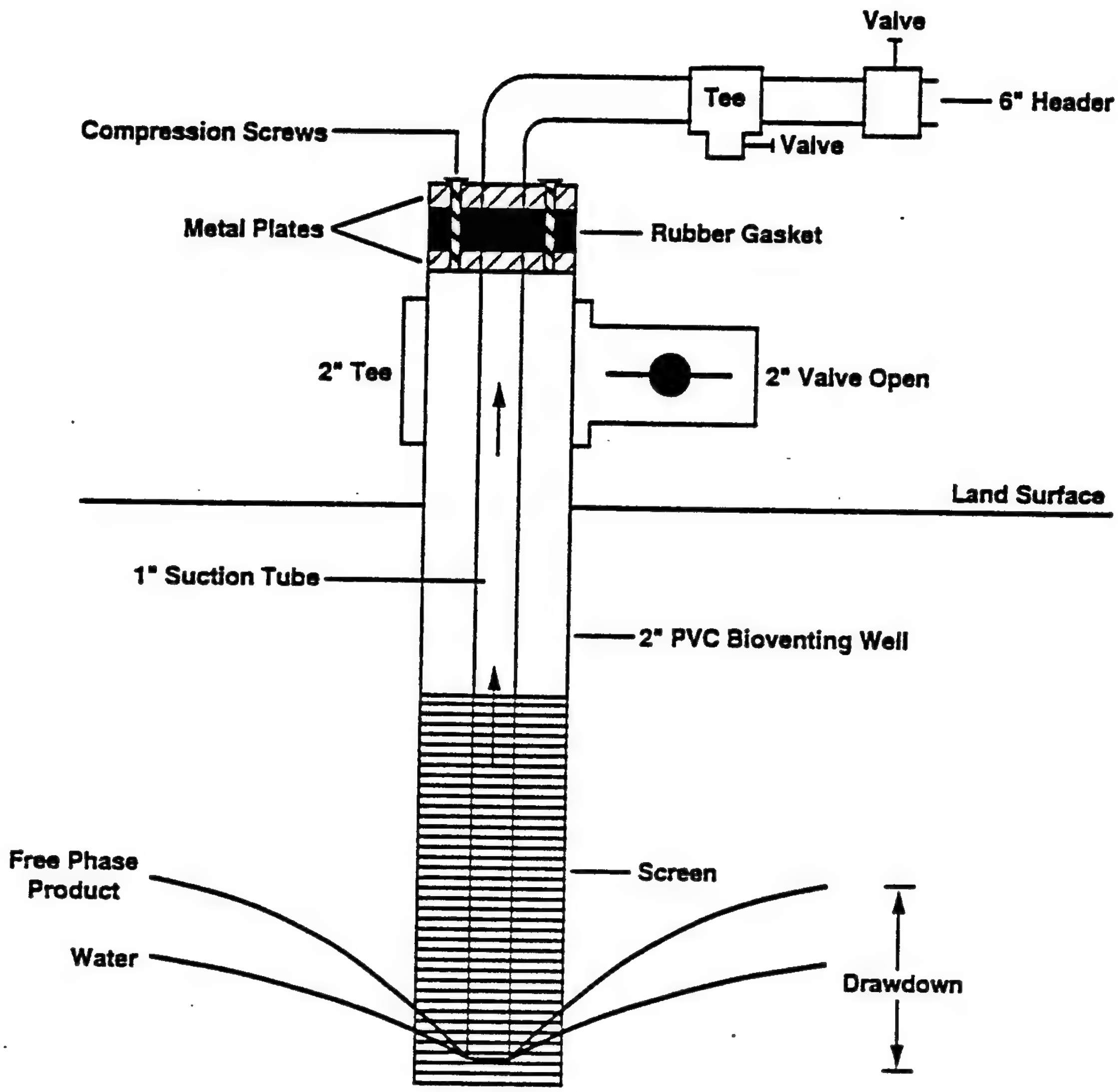

Figure 5. Slurper Tube Placement for the Drawdown Simulation Recovery Test

thickness for the drawdown pump test is shown in Table 1. The test was run for 5 hours. The test was prematurely terminated because carbon canisters used to remove the petroleum compounds from the off-gas were depleted and TPH concentrations in the vapor emissions would have exceeded the regulatory limit if the system was not shut down. Throughout the test, the position of the dip tube was adjusted to maintain a depth of approximately 1.8 ft below the oil/water interface to account for tidal changes in the water table. The LNAPL recovery rates and groundwater extraction rates were quantified over time, and all data needed to assess drawdown pump test efficiency were recorded. The data collected for this test is summarized in Appendix D.

3.5.5 Off-Gas Sampling and Analyses

Soil gas samples were collected from the bioslurper off-gas during the bioslurping test. Samples were collected in Summa™ canisters before the carbon treatment and after the carbon treatment and were labeled Hick-1 and Hick-2, respectively. The samples were sent under chain of custody to Air Toxics, Ltd., in Rancho Cordova, California, for analyses of BTEX and TPH.

3.5.6 Extracted Groundwater Sampling and Analyses

Two groundwater samples were collected from the oil/water separator during the bioslurping test. Samples were collected 20 minutes apart and were labeled HIC-1-EFF and HIC-2-EFF. Samples were collected in 40-mL septa vials with HCl preservative. Samples were checked to ensure no headspace and were then shipped on ice and sent under chain of custody to the Environmental Laboratory of the Pacific, Honolulu, Hawaii for analyses of BTEX and TPH.

Groundwater extracted during the skimmer and bioslurper tests also was analyzed in the field for lead concentration. Samples were analyzed using a Hach DR 100 colorimeter. Sampling and analyses was conducted as specified in the Hach operation manual.

3.6 Slug Testing

The slug tests were performed at Area H on March 15, 1995. Slug testing was performed in the extraction well used for the pilot testing (monitoring well GT-H9). The results of the slug tests help quantify the hydraulic properties of the test well and the aquifer near the well. The slug tests

involved creating an instantaneous change in head in the perspective well. The instruments used to perform the slug tests were a pressure transducer (Model PDX-260) and a Hermit Model SE2000C data logger, both of which are manufactured by In Situ, Inc. The slug test was conducted by dropping a weighted 3 ft PVC tube (the slug) to displace the well water. After equilibrium was obtained in the well, the slug (PVC tube) was quickly removed and the Hermit data logger was started to record the head pressure above the transducer. The test was stopped once the amount of head above the transducer reached its original level (i.e., the reference level).

3.7 Soil Gas Permeability Testing

The soil gas permeability test data were collected during the bioslurping pumping operation. Before a vacuum was established in the extraction well, the initial soil gas pressures at the three installed monitoring points were recorded. The start of the bioslurping test created a steep pressure drop in the extraction well; the drop in pressure was the beginning of the soil gas permeability testing. Soil gas pressures were measured in each of the three monitoring points at all depths to track the outward propagation of the pressure drop in the extraction well. Pressure readings were taken approximately every 1 to 2 minutes for the first hour, then approximately every 10 minutes for the following hour. The data collected for this test are summarized in Appendix E.

3.8 In Situ Respiration Testing

Air containing approximately 2% helium was injected into the soil at Area H for approximately 24 hours beginning on March 13, 1995. The setup for the in situ respiration test is described in the *Test Plan and Technical Protocol for Bioventing* (Hinchee et al., 1992). A ½-hp diaphragm pump was used for air and helium injection. Air and helium were injected through the following monitoring points at the depths indicated: HI-MPA-12.0′ and HI-MPC-13.5′. After the air/helium injection was terminated, soil gas concentrations of oxygen, carbon dioxide, and TPH were monitored periodically. The respiration test was terminated on March 16, 1995. Oxygen utilization rates and biodegradation rates were calculated as described in Hinchee et al. (1992). Raw data for these tests are presented in Appendix F.

Helium concentrations were measured during the in situ respiration test to quantify helium leakage to or from the surface around the monitoring points. Helium loss over time is attributed to

either diffusion or leakage. A rapid drop in helium concentration followed by a leveling is an indication of leakage. A gradual loss along with an apparent first-order curve is an indicator of diffusion. As a rough estimate, the diffusion of gas molecules is inversely proportional to the square root of the molecular weight of the gas. Based on molecular weights of 4 for helium and 32 for oxygen, helium diffuses about 2.8 times faster than oxygen, or the diffusion of oxygen is 0.35 times the rate of helium diffusion. As a general rule, we have found that if helium concentrations are at least 50 to 60% of the initial levels at test completion, measured oxygen uptake rates are representative. Greater helium loss indicates a problem, and oxygen utilization rates are not considered representative.

3.9 Continuous Measurement of Groundwater Depth

Groundwater depth was measured continuously for approximately 16 hours on March 15, 1995 to document depth changes due to tidal influences. A Hermit Model SE2000C data logger manufactured by In Situ, Inc. was used to record groundwater depth every 15 minutes.

4.0 RESULTS

This section documents the results of the preliminary site characterization, the comparative LNAPL recovery pumping studies, and other supporting tests conducted at the Hickam AFB site.

4.1 Baildown Test Results

The initial LNAPL thickness observed in monitoring well GT-H9 was 3.98 ft. A total volume of 3.2 gallons was removed by hand bailing. Product recovery was relatively rapid with LNAPL thickness recovered to 3.95 ft after approximately 7 hours. LNAPL thickness recovered no further during the remainder of the test (Table 3).

Table 3. Results of Baildown Test in Monitoring Well GT-H9

Time	Depth to LNAPL (ft)	Depth to Groundwater (ft)	LNAPL Thickness (ft)
Initial Reading (3/7/95 1100 hrs)	14.61	18.59	3.98
3/7/95 1115	16.25	17.25	1.0
3/7/95 1123	15.58	16.82	1.24
3/7/95 1130	15.56	16.87	1.31
3/7/95 1145	15.54	16.97	1.43
3/7/95 1230	15.48	17.25	1.77
3/7/95 1302	15.42	17.46	2.03
3/7/95 1341	15.44	17.84	2.40
3/7/95 1414	15.36	18.04	2.68
3/7/95 1500	15.14	18.22	3.08
3/7/95 1835	14.64	18.59	3.95

4.2 Soil Sample Analyses

Table 4 shows the BTEX and TPH concentrations measured in the soil sample collected from Area H. The concentrations of benzene, toluene, and TPH were below detection limits, whereas only small concentrations of ethylbenzene and xylenes were detected. A sieve analysis also was performed on the soil sample to determine the grain-size distribution of the soils at the bioslurper site. The analysis indicated that the site soil consisted of 6.6% gravel, 45.9% sand, and 47.5% silt and clay. The results of the sieve analysis are presented in Table 5.

Table 6 illustrates results from soil samples collected for drum disposal at the request of the base. The concentrations of TPH and BTEX compounds in sample D-1 were below detection limits as were concentrations of TPH and xylenes in sample D-2. Small concentrations of benzene, toluene, and ethylbenzene were detected in sample D-2. Analyses also were completed on the soil samples to determine the concentration of PAHs. All analyses for PAH compounds were below the detection limit. Cadmium, chromium, and lead analyses of the soils indicated the concentration of each of these elements also was below detection limits.

Table 4. BTEX and TPH Concentrations in Soil Samples from Area H, Hickam AFB, HI

Parameter	Concentration (mg/kg)
	HI-MPA-13-13.5
TPH (Purgeable)	<5.0
Benzene	<0.0050
Toluene	<0.0050
Ethylbenzene	0.0070
Xylenes	0.021

Table 5. Sieve Analysis of Soil from Area H, Hickam AFB

Depth (ft)	Density (g/cm^3)	Porosity (%)	U.S. Standard Sieve Size	Cumulative % Passing
13.0 - 13.5	2.74	57.9	1½ inch	100
			¾ inch	100
			⅜ inch	96.1
			No. 4	93.4
			No. 10	89.6
			No. 20	80.5
			No. 40	69.8
			No. 60	62.2
			No. 100	55.8
			No. 200	47.5

Table 6. **PAHs and Metals Concentrations of Soil Samples from Area H, Hickam AFB, HI**

Analyte	Concentration by Sample	
	D-1	D-2
TPH	<5.0	<5.0
Benzene	<0.0050	0.010
Toluene	<0.0050	0.0050
Ethylbenzene	<0.0050	0.018
Xylenes	<0.0050	<0.0050
Metals		
Cadmium (mg/L)	<0.050	<0.050
Chromium (mg/L)	<0.050	<0.050
Lead (mg/L)	<0.20	<0.20
PAHs		
Acenaphthene (mg/kg)	<50	<50
Benzo(a)pyrene (mg/kg)	<1.0	<1.0
Fluoranthene (mg/kg)	<250	<250
Naphthalene (mg/kg)	<50	<50

4.3 LNAPL Recovery Test Results

The skimmer, bioslurper, and drawdown pump test data are summarized in Table 7. LNAPL recovery versus time is plotted in Figure 6 for each test configuration. Results for each test configuration are discussed in the following sections.

Table 7. Pilot Test Results at Area H, Hickam AFB, Hawaii

Parameter	Skimmer Pump Test		Bioslurper Test		Drawdown Test	
	LNAPL	Water	LNAPL	Water	LNAPL	Water
Total Recovered (gal)	69.0	1268.6	20.8	530.0	85.1	890.0
Recovery Rate in Day 1 (gal/day)	51.6	664.0	90.9	2312.7	408.5	4272.0
Recovery Rate in Day 2 (gal/day)	16.5	546.6	NA	NA	NA	NA
Average Recovery Rate (gal/day)	36.07	663.08	90.9	2312.7	408.5	4272.0

NA = Not applicable. Bioslurper and drawdown tests were conducted for less than 1 day each.

Specify well head pressure
Drawdown depth

4.3.1 Skimmer Test Results

The bioslurper system was operated in the skimmer configuration for approximately 2 days (46 hours). A total of 69.0 gallons of LNAPL and 1,268.6 gallons of groundwater were recovered during the test. Daily recovery averages were 34.5 gal/day for LNAPL and 634.3 gal/day for groundwater.

As shown in Figure 6, the rate of LNAPL recovery decreased greatly during the 2-day skimmer test, as indicated by the decrease in slope of the recovery curve. During the first 10 hours of the test, the average recovery rate was approximately 72 gallons/day. During the last 10 hours of the skimmer test, the average recovery rate was approximately 14 gallons/day.

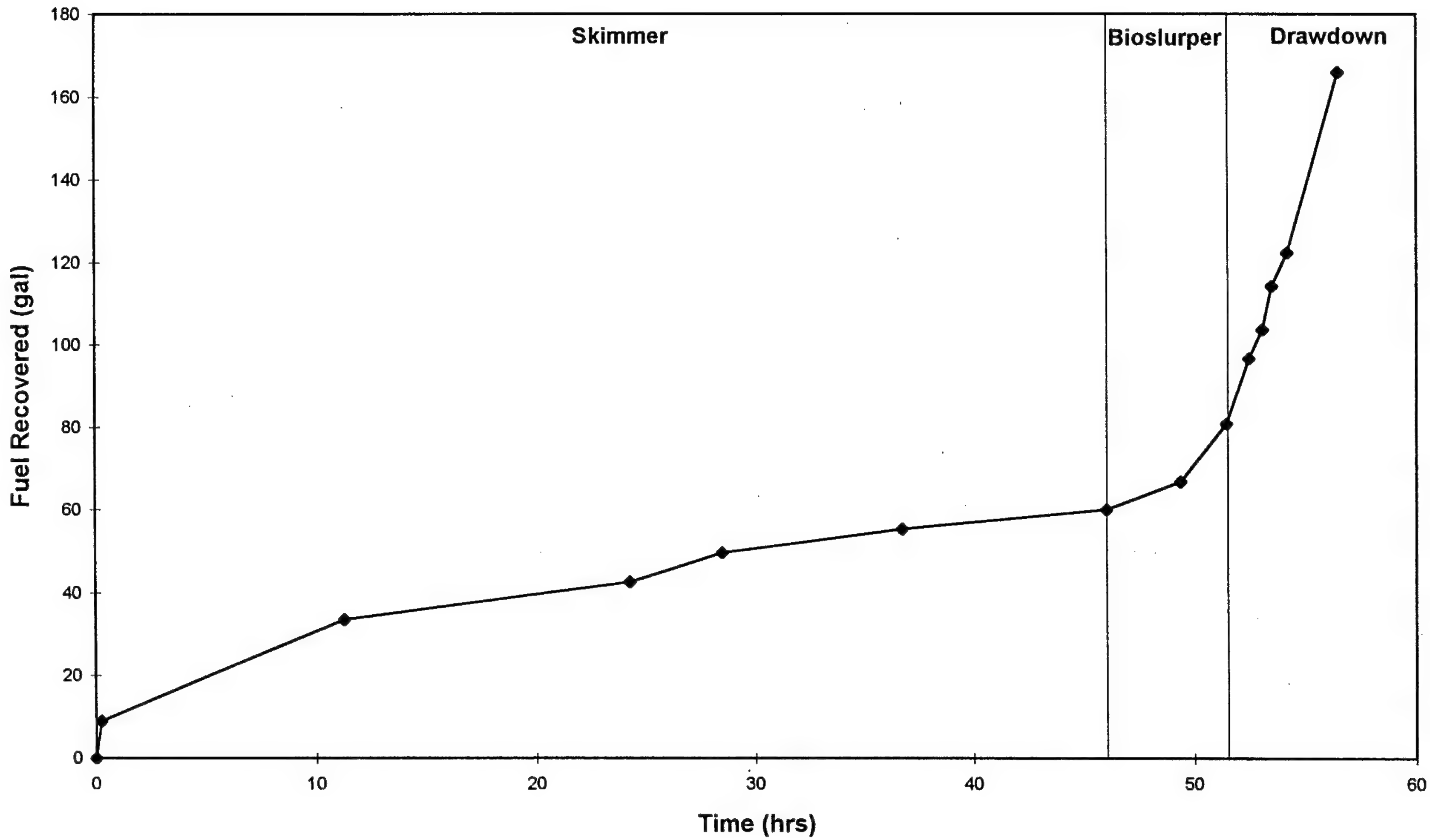

Figure 6. Total LNAPL Recovery as a Function of Time During Each Test Sequence

4.3.2 Bioslurper Test Results

Immediately after the skimmer test, the bioslurper system was reconfigured to the bioslurping mode. The bioslurping test was started 4 hours after the skimmer test was completed. The initial measurements of LNAPL thickness are recorded in Table 1. Due to the short time period between the two tests, the well did not fully recover to the original product depth seen prior to the skimmer test.

The bioslurper system was operated in the vacuum-enhanced configuration for approximately 0.21 days (5.5 hours). A total of 20.8 gallons of LNAPL and 530 gallons of groundwater were recovered during the test. Daily recovery averages were 90.9 gal/day for LNAPL and 2,312.7 gal/day for groundwater (Table 7). Analyses of the extracted groundwater and off-gas were conducted. These results are discussed in Section 4.4.

The vacuum-exerted wellhead pressure on monitoring well GT-H9 was maintained at approximately 0.7 inch H_2O throughout the bioslurper pump test. This provides for an equivalent hydraulic gradient increase to a 0.7-inch groundwater depression in the well.

Figure 6 illustrates that the rate of LNAPL was greater during the bioslurper test than during the skimmer test. The sudden increase in recovery rate indicates that LNAPL, although not mobile during the skimmer test, was mobilized to the well under vacuum-enhanced conditions. The LNAPL recovery rate versus time was not plotted for these results because the short operation time does not allow for a useful analysis.

These preliminary results demonstrate the potential for successful bioslurping at this site; however, operation with a properly sealed and screened well will produce a more efficient bioslurping system. Therefore, these results cannot be assumed to be representative of actual operation under more optimal conditions.

4.3.3 Drawdown Test

The bioslurper system was reconfigured for the drawdown mode, and the drawdown pump test was initiated approximately 40 hours after completion of the bioslurper test. The bioslurper system was operated in the drawdown simulation configuration for approximately 0.21 days (5.0

hours). A total of 85.1 gal of LNAPL and 890.0 gal of groundwater were recovered during the test. Daily recovery averages compute to 408.5 gal/day for LNAPL and 4,272.0 gal/day for groundwater.

The data in Figure 6 indicate that the rate of LNAPL recovery is greater during the drawdown test than during the skimmer test or the bioslurper test. The rate of LNAPL recovery is nearly constant throughout the drawdown test, although the length of time of the drawdown test is relatively short compared to the length of the skimmer test. The first 5 hours of a test should not be assumed to provide an accurate assessment of the efficiency of a long-term test. In addition, due to the screening of the monitoring well, results from the bioslurper test are not representative and cannot be adequately compared to the drawdown test results.

4.4 LNAPL, Extracted Groundwater, and Off-Gas Analyses

During the operation of the bioslurper pump test, groundwater and fuel[1] samples from the oil/water separator were collected. The contaminant concentrations in the groundwater from the oil/water separator are shown in Table 8. TPH concentrations ranged from 32 to 232 mg/L, while BTEX concentrations ranged from 0.10 mg/L (toluene) up to 4.28 mg/L (benzene). Field tests for lead concentration detected concentrations of 4 μg/L in duplicate samples.

Off-gas samples also were collected from the bioslurper system off-gas stack. The results from the off-gas samples are shown in Table 9. Given a vapor discharge rate for the bioslurper test of approximately 4,600 ft^3/day (3.2 cfm), approximately 0.030 lb/day of TPH was emitted to the air during the bioslurper test. Prior to carbon treatment, the off-gas produced 132 lb/day of TPH. Therefore, when the carbon treatment system was depleted (approximately 5.5 hours after the initiation of the test), the system had to be turned off to comply with air emission regulations.

4.5 Slug Test Results

Figure 7 is a graph of one of the slug tests performed at Area H. The raw data and replicate slug test data and results are given in Appendix G. The results of the slug tests indicate that the average hydraulic conductivity of the area surrounding monitoring well GT-H9 was 12.67 ft per day.

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[1] The analytical laboratory did not analyze the fuel as specified on the chain-of-custody form. Therefore, we requested to have the fuel samples sent to Alpha Analytical for analysis. These results should be completed by June 9, 1995.

Table 8. **BTEX and TPH Concentrations in Extracted Groundwater During the Bioslurper Test at Area H, Hickam AFB, HI**

Parameter	Concentration (mg/L)	
	HIC-1-EFF	HIC-2-EFF
TPH (Purgeable)	32	232
Benzene	4.24	4.28
Toluene	0.102	0.202
Ethylbenzene	0.754	2.780
Total Xylenes	1.437	1.700

Table 9. **Analytical Results of Off-Gas Samples During Bioslurping Test, Area H, Hickam AFB, HI**

Parameter	Concentration (ppmv)	
	Hick-1	Hick-2
TPH (as jet fuel)	100,000	26
Benzene	<24	<0.084
Toluene	<24	<0.084
Ethylbenzene	95	0.18
Total Xylenes	100	0.28

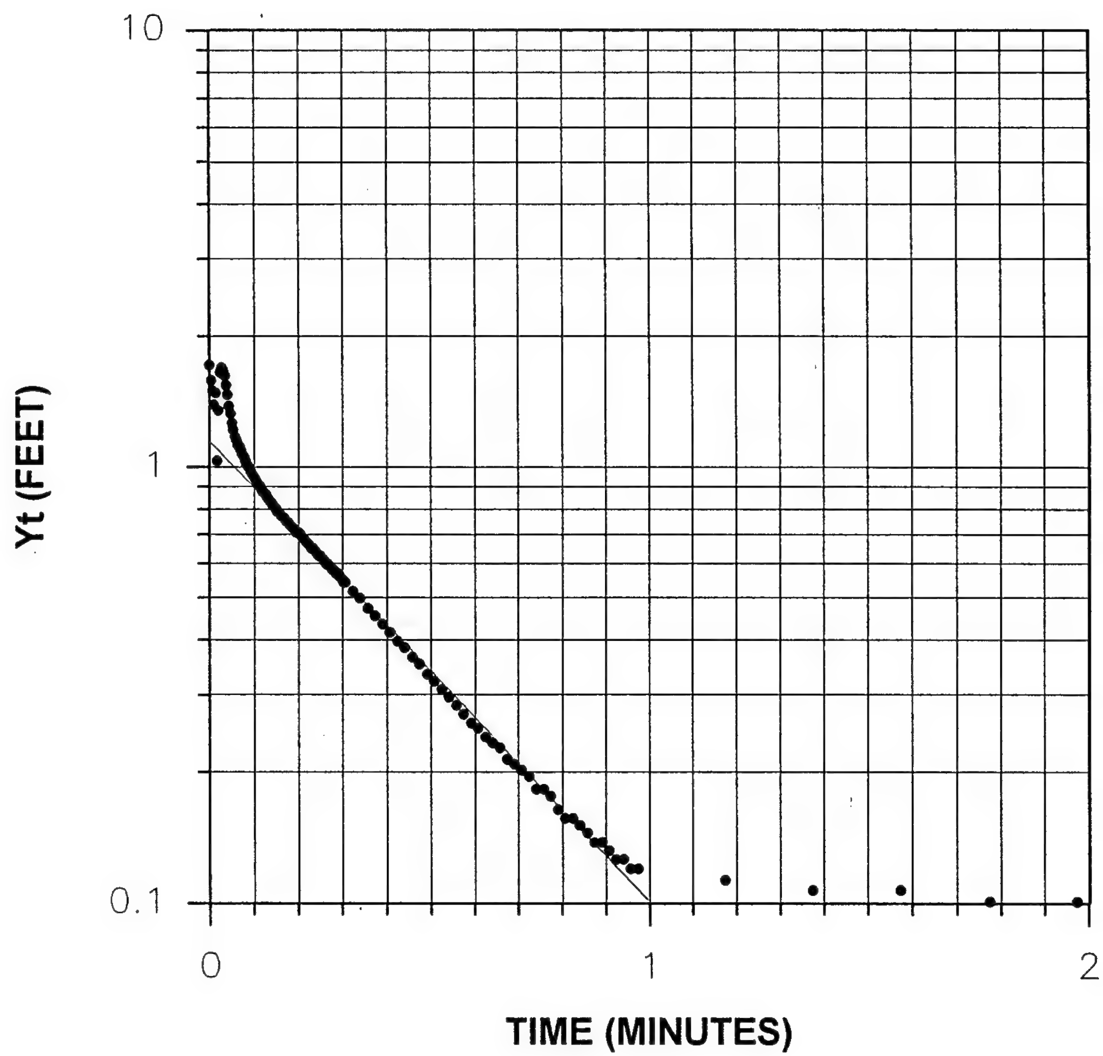


Figure 7. Level Variation During an Example Slug Test in Well #GT-H9

4.6 Bioventing Analyses

4.6.1 Soil Gas Permeability and Radius of Influence

The radius of influence is calculated by plotting the log of the pressure change at a specific monitoring point versus the distance from the extraction well. The radius of influence is defined as the distance from the extraction well where 0.1 inch of H_2O can be measured. As shown in Figure 8, due to the problem with the screened interval and possible seal of the monitoring well, results were inconclusive from permeability testing during bioslurping. In general, monitoring points were screened within the volcanic rock; however, because the majority of flow was within the upper permeable zone, neither significant oxygen increases nor pressure changes were detected at the monitoring points. Therefore, a radius of influence could not be determined during this test.

4.6.2 In Situ Respiration Test

The results of the in situ respiration test are presented in Appendix F. Each figure in Appendix F illustrates the oxygen, carbon dioxide, and helium concentrations as a function of time. An example of typical oxygen utilization and carbon dioxide production at this site is shown in Figure 9, which shows oxygen, carbon dioxide, and helium at monitoring point HI-MPA-12.0′. The rates of oxygen utilization and carbon dioxide production and the corresponding biodegradation rates are summarized in Table 10. The biodegradation rates measured at this site were relatively high with values ranging from 5.1 to 21 mg/kg/day.

Loss of helium was insignificant at all monitoring points, indicating that the monitoring points were well-sealed and that the oxygen depletion observed was a result of biodegradation.

Table 10. Oxygen Utilization Rates During the In Situ Respiration Test at Hickam AFB

Monitoring Point	Oxygen Utilization Rate (%/hr)	Biodegradation Rate (mg/kg/day)
HI-MPA-12′	0.32	5.1
HI-MPC-13.5′	1.3	21

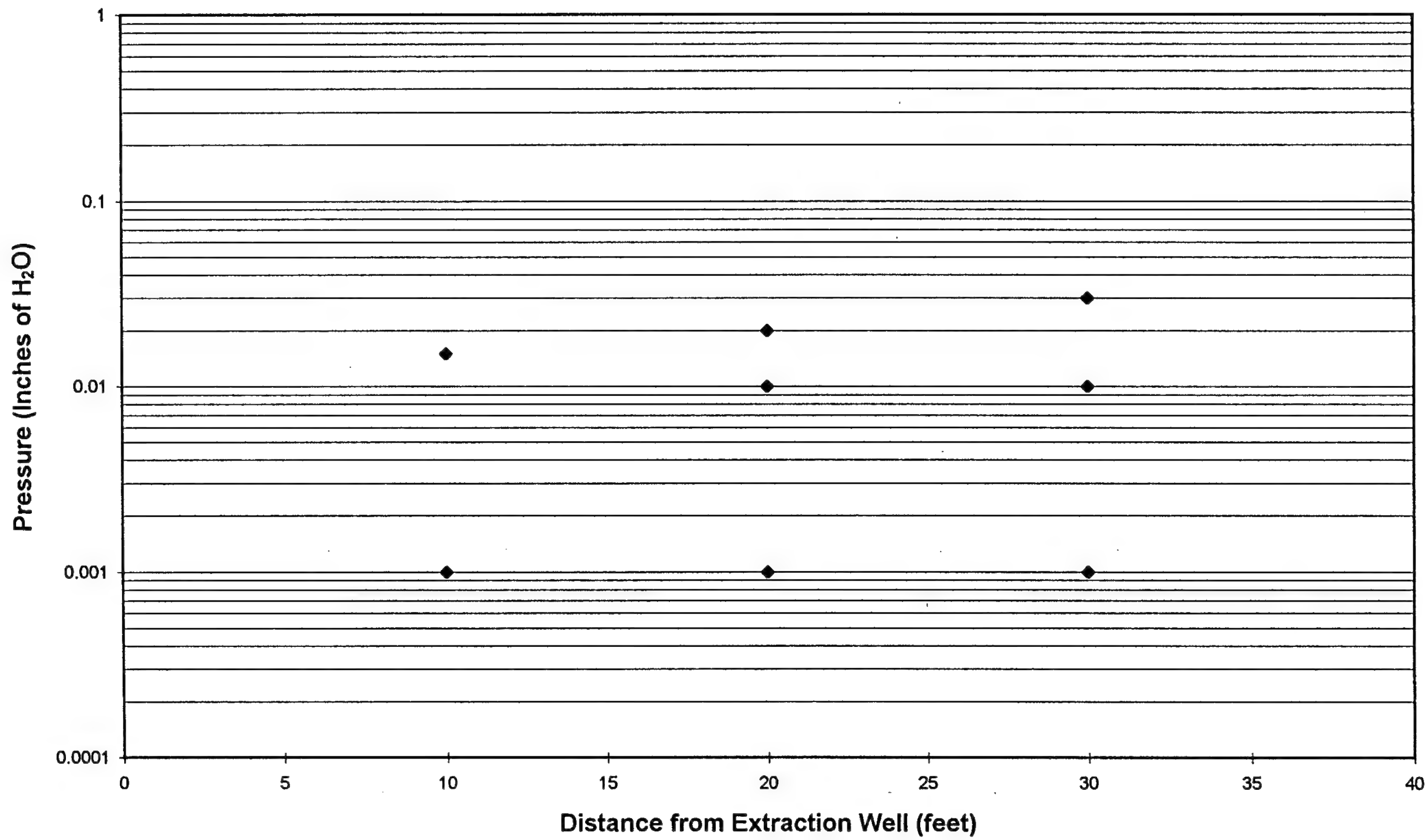


Figure 8. Soil Gas Pressure Change as a Function of Distance

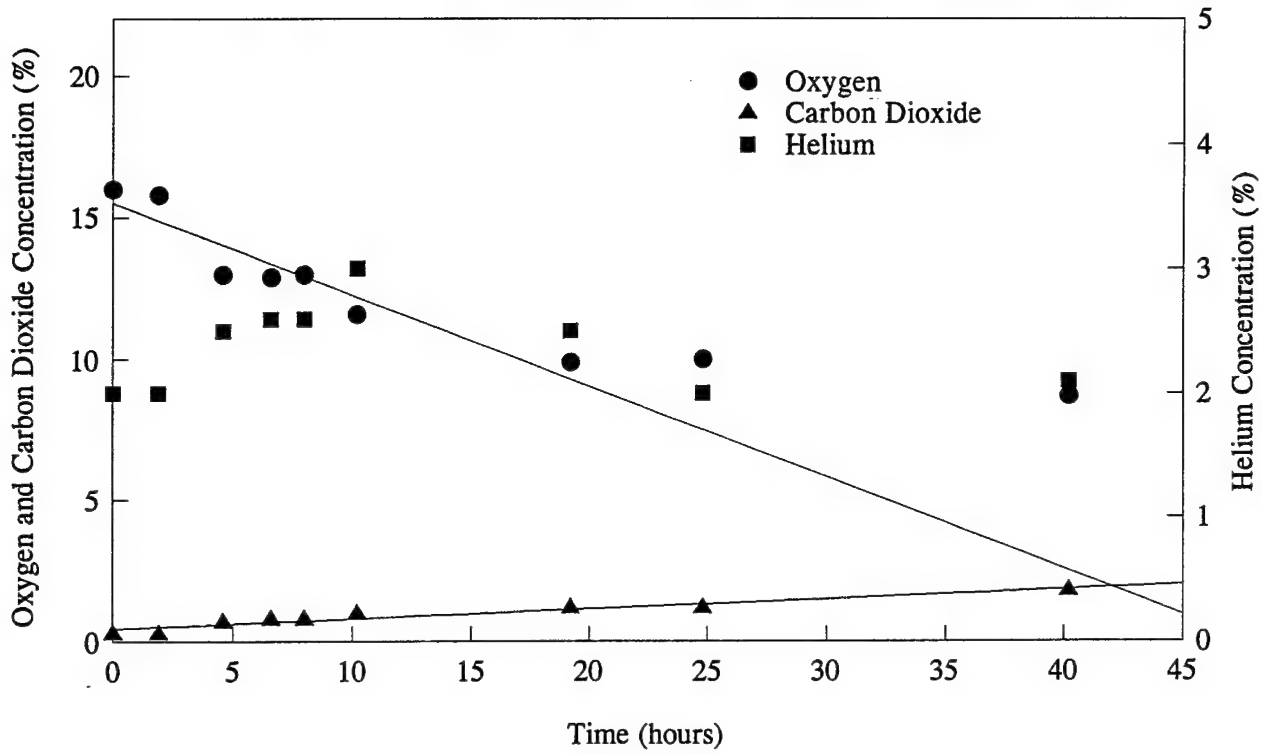


Figure 9. **Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point HI-MPA-12.0′**

4.7 Groundwater Fluctuations

Groundwater depth was measured continuously for approximately 16 hours on March 15 to examine changes due to tidal fluctuations. Results from this monitoring are presented in Figure 10. The groundwater depth fluctuated approximately 0.5 to 0.6 ft during the course of the monitoring. These depth fluctuations would have to be considered during long-term bioslurping operation.

5.0 DISCUSSION

Each of the three recovery configurations tested was able to recover LNAPL from monitoring well GT-H9. Unfortunately, the bioslurping configuration could not be properly evaluated due to improperly screened and/or sealed wells. At this site, there are relatively sandy soils to a depth of approximately 5 ft, then a lithology change to relatively impermeable volcanic rock with groundwater at approximately 15 ft. With part of the screened interval in a much more permeable zone, during bioslurping the majority of vapor flow occurred in this region, reducing the effective vacuum at the wellhead. Based on results from the baildown testing, this site is likely to be an excellent candidate for bioslurping; however, new wells would have to be installed with their entire screened interval below the permeable zone.

Due to the problem with the screened interval of the monitoring well, results were inconclusive from permeability testing and monitoring of oxygen concentrations during bioslurping. All monitoring points were screened within the volcanic rock; however, because the majority of flow was within the upper permeable zone, neither significant oxygen increases nor pressure changes were detected at the monitoring points. Results from the in situ respiration testing did demonstrate relatively high microbial activity with an average biodegradation rate of 13 mg/kg/day or approximately 4,800 mg/kg/year.

Implementation of bioslurping at Area H, Hickam AFB likely would facilitate enhanced free product recovery and simultaneous in situ biodegradation of hydrocarbons in the vadose zone via bioventing given properly screened wells. The feasibility of implementing bioslurping would depend on long-term requirements for vapor treatment and disposition requirements for extracted groundwater.

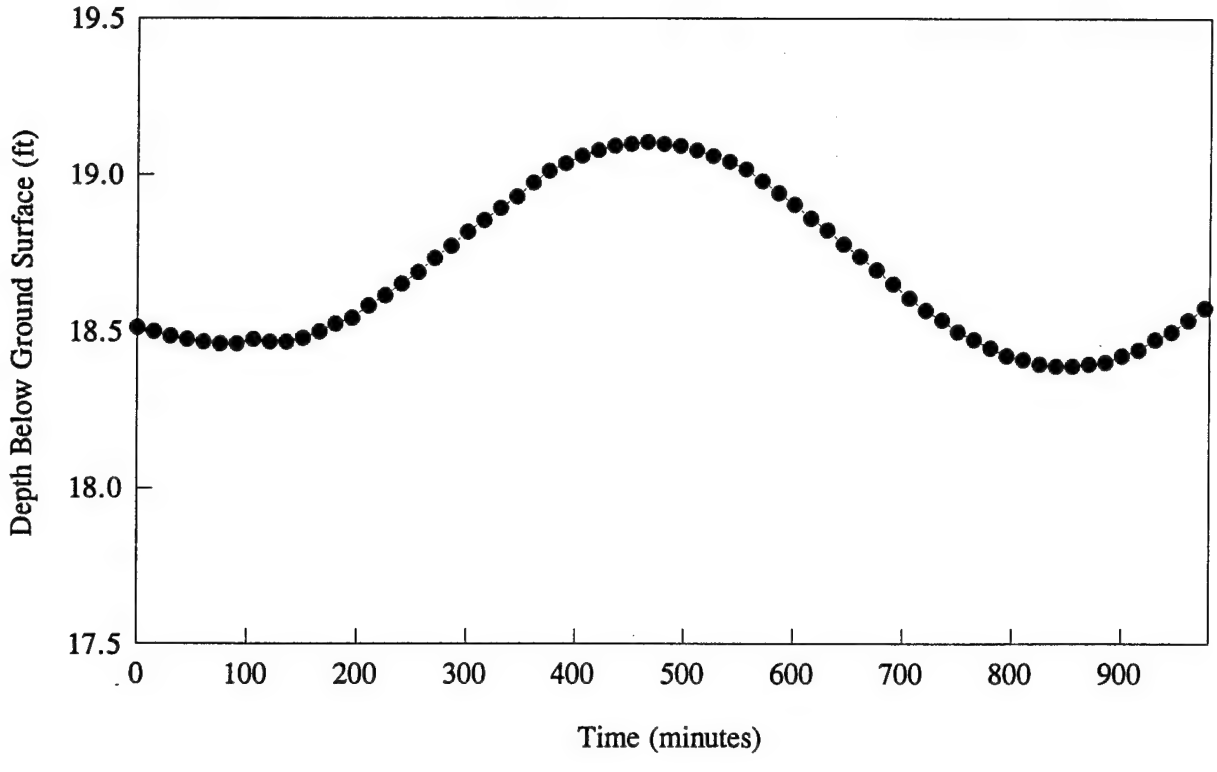


Figure 10. Groundwater Depth as a Function of Time at Area H, Hickam AFB, HI

6.0 REFERENCES

Battelle. 1995. *Test Plan and Technical Protocol for Bioslurping*, Report prepared by Battelle Columbus Operations for the U.S. Air Force Center for Environmental Excellence, Brooks Air Force Base, Texas.

Hinchee, R.E., S.K. Ong, R.N. Miller, D.C. Downey, and R. Frandt. 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing* (Rev. 2), Report prepared by Battelle Columbus Operations, U.S. Air Force Center for Environmental Excellence, and Engineering Sciences, Inc. for the U.S. Air Force Center for Environmental Excellence, Brooks Air Force Base, Texas.

APPENDIX A

SITE-SPECIFIC TEST PLAN FOR BIOSLURPER FIELD ACTIVITIES AT HICKAM AFB, HAWAII

Battelle
. . . *Putting Technology To Work*
505 King Avenue
Columbus, Ohio 43201-2693
Telephone (614) 424-6424
Facsimile (614) 424-5263

January 24, 1995

15 CES/CEVR
75 H Street
Hickam AFB, HI 96853-5233

Attention: Ms. Leanne Tanouye

Dear Leanne:

FINAL SITE-SPECIFIC TEST PLAN FOR BIOSLURPER TESTING AT HICKAM AFB (A002)

Attached is the final version of the test plan for bioslurper field activities at Hickam Air Force Base, Hawaii. If you have any questions, please feel free to call me at (614) 424-6122.

Sincerely,

Jeffrey A. Kittel
Program Manager
Environmental Restoration Department

JAK:bms
Attachment
cc: Mr. Patrick Haas
Mr. Mark Rounsavill (Letter only)
Ms. Petra Rosales (Letter only)
Mr. Leon Sulton (Letter only)

TEST PLAN FOR BIOSLURPER FIELD ACTIVITIES AT HICKAM AIR FORCE BASE, HAWAII

January 24, 1995

The Air Force Center for Environmental Excellence is conducting a nationwide application of an innovative technology for free-product recovery and soil bioremediation. The technology tested in the Bioslurper Initiative is vacuum-mediated free-product recovery/bioremediation (bioslurping). The field test and evaluation are intended to demonstrate the initial feasibility of bioslurping by measuring system performance in the field. System performance parameters, mainly free-product recovery, will be determined at numerous sites. Field testing will be performed at many sites to determine the effects of different organic contaminant types and concentrations and different geological conditions on bioslurping effectiveness.

Plans for the field test activities are presented in two documents. The first is the overall test plan and technical protocol for the entire program titled, Test Plan and Technical Protocol for a Field Treatability Test for Bioslurping (November, 1994). The overall plan is supplemented by plans specific for each test site. This letter report is the site-specific supplement for Hickam Air Force Base, Hawaii.

The overall test plan and protocol was developed as a generic plan for the Bioslurper Initiative to improve the accuracy and efficiency of test plan preparation. The field program requires installation and operation of the bioslurping system supported by a wide variety of site characterization, performance monitoring, and chemical analysis activities. The basic methods to be applied from site to site do not change. Preparation and review of the overall plan allows efficient documentation and review of the basic approach to the test program. Peer and regulatory review were performed for the overall plan to ensure the credibility of the overall program. Details required for application at each site are covered by individual supplements for that site. The concise site-specific plan effectively communicates regulatory background to base personnel. This letter report was prepared based on site-specific information received by Battelle from Hickam AFB and other pertinent site-specific information to support the generic test plan.

Site-specific information for Hickam AFB included data for two potential test locations. The potential test locations are Fuel Recovery Area G and Fuel Recovery Area H. An initial review of the data indicates that Fuel Recovery Area H is the most likely candidate for the bioslurper pilot test. Specifically, Well No. GT-H9 appears to be the best candidate for the bioslurper field test. If Fuel Recovery Area H is unsuitable for testing, Fuel Recovery Area G is a viable alternative for bioslurper field test activities.

Site Description

Figure 1 is a site map that depicts the two areas of interest (Fuel Recovery Areas G and H) at Hickam AFB. Also, Tables 1 and 2 provide the subsurface fuel thickness measurements data for all the wells located within Fuel Recovery Areas G and H, respectively, during the past 6 years. Table 3 gives fuel thickness measurements of various wells on December 7, 1993. From these data, the wells that are most likely to yield significant amounts of free product have been identified. Well No. GT-H9 in Fuel Recovery Area H had the largest fuel thickness in the May 2, 1994, measurement and has shown

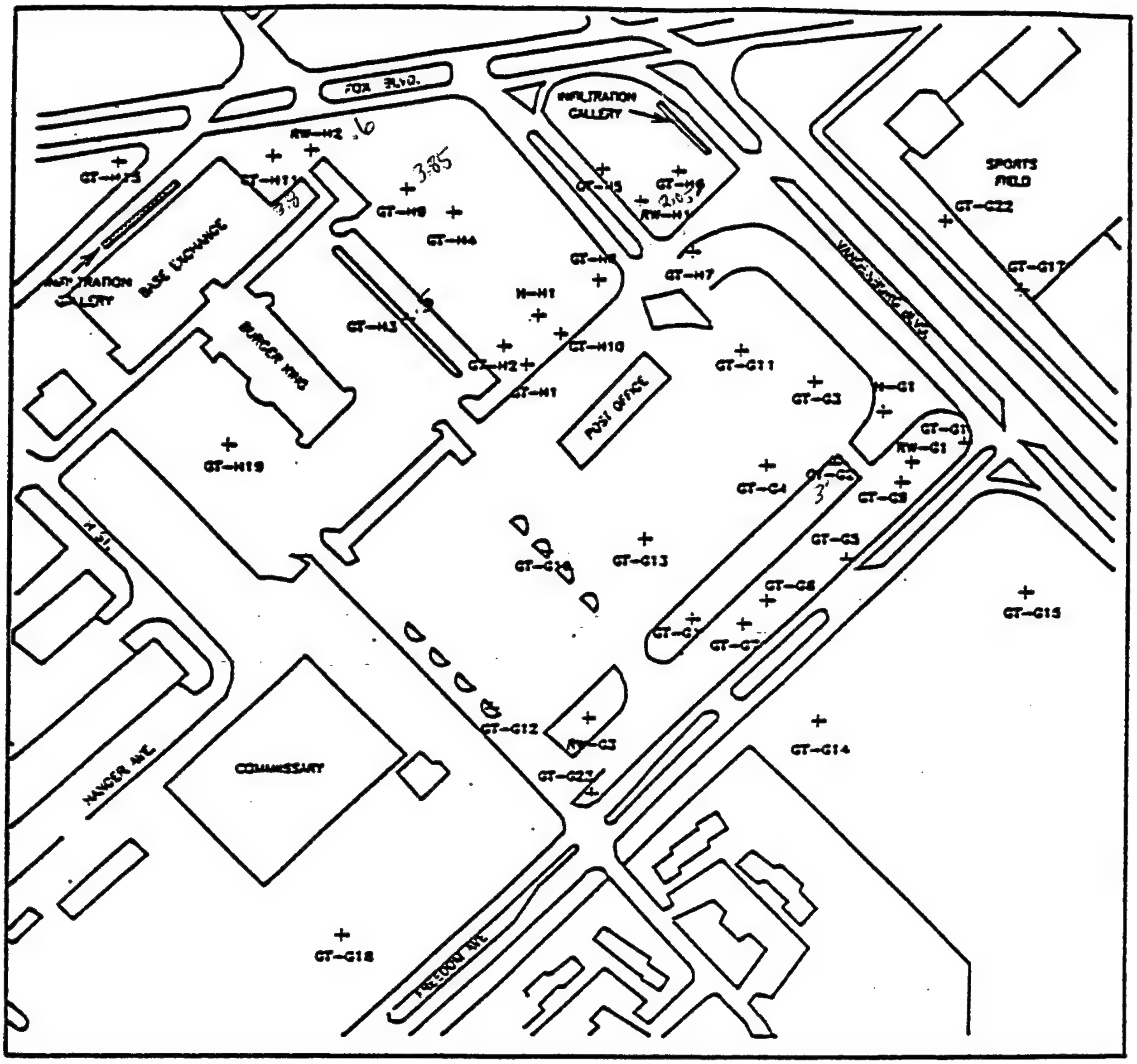


Figure 1. Location of Areas of Interest for Bioslurper Testing at Hickam AFB.

a sustained fuel thickness throughout the measurement period. Fuel recovery Area G will be used as a substitute bioslurper test site, if required. Site characterization (see Section 2) will start with Area H, focusing on Well No. GT-H9. If preliminary site characterization indicates that Fuel Recovery Area H is unsuitable, or if site logistics prevent the use of wells in that area, Fuel Recovery Area G will be used as a substitute bioslurper test site. The well in Area G that appears to be the best candidate for the bioslurper extraction well is Well No. GT-G2. A general arrangement of the bioslurping well and monitoring points is shown in Figure 2.

The organic liquid contaminant in the candidate test sites at Hickam AFB is diesel fuel. The soil and groundwater concentration of benzene from the diesel fuel ranges from 0.010 to 0.020 mg/L, and the concentration of total petroleum hydrocarbons (TPH) ranges from 6.0 to 7.0 mg/L.

Table 1. Subsurface Apparent Fuel Thickness for Wells in Fuel Recovery Area G

Subsurface Fuel Thickness Measurements (ft)*											
Summary Sheet											
Well	11-Mar-88	20-Dec-90	29-May-91	31-Jul-92	7-Oct-92	4-Jan-93	28-May-93	7-Dec-93	7-Jan-94	28-Feb-94	2-May-94
RW-G1	1.34	N/A	N/A	3.00	0.00	0.52	3.20	3.30	3.11	2.17	N/A
RW-G2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	N/A
RW-G3	0.38	0.002	N/A	0.00	0.00	0.00	0.00	0.00	0.00	N/A	N/A
H-G1	4.01	Gone	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GT-G1	1.28	2.95	2.35	3.50	3.80	3.85	2.60	N/A	0.00	N/A	0.90
GT-G2	3.92	3.44	3.45	1.70	3.80	3.78	3.81	N/A	3.50	3.31	3.40
GT-G3	2.65	3.15	3.51	3.30	3.65	3.75	3.53	3.20	3.05	N/A	N/A
GT-G4	0.00	1.5	0.35	2.40	2.85	2.86	1.95	0.00	0.34	N/A	N/A
GT-G5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.00
GT-G6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.00
GT-G7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.00
GT-G8	2.94	2.85	2.45	0.00	0.00	3.35	2.86	2.75	2.72	N/A	N/A
GT-G9	1.54	2.64	1.95	3.30	0.00	3.46	3.50	1.50	2.30	N/A	N/A
GT-G10	4.26	3.20	3.31	3.35	3.60	3.58	3.40	3.30	3.22	N/A	N/A
GT-G11	0.00	2.35	4.24	3.75	4.28	4.34	3.58	N/A	3.75	2.64	2.60
GT-G12	4.04	3.80	3.18	3.75	4.00	3.97	3.73	3.45	3.29	N/A	N/A
GT-G13	2.97	3.20	3.20	2.80	2.11	2.11	2.80	N/A	2.85	N/A	2.60
GT-G14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.00	N/A	N/A
GT-G15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.00	N/A	N/A
GT-G16	3.04	Gone	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.08	N/A
GT-G17	3.82	3.20	2.58	3.55	0.00	0.00	0.00	N/A	2.44	N/A	N/A
GT-G18	0.31	0.00	0.05	0.00	0.00	0.00	Dry	N/A	0.00	N/A	0.00

Table 1. Subsurface Apparent Fuel Thickness for Wells in Fuel Recovery Area G (continued)

Subsurface Fuel Thickness Measurements (ft)*											
Summary Sheet											
Well	11-Mar-88	20-Dec-90	29-May-91	31-Jul-92	7-Oct-92	4-Jan-93	28-May-93	7-Dec-93	7-Jan-94	28-Feb-94	2-May-94
GT-G19	0.00	0.00	0.00	0.00	0.00	0.00	Dry	N/A	Mud	N/A	N/A
GT-G20	0.31	0.00	0.52	0.00	0.00	0.00	0.00	N/A	0.00	N/A	N/A
GT-G21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		N/A	N/A
GT-G22	0.00	0.00	0.00	Gone	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GT-G23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.00	N/A	0.00
GT-G24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.00	N/A	0.00

N/A = no measurement taken.
* = Based on the information provided, these data are assumed to be product thickness measurements.

Table 2. Subsurface Fuel Thickness for Wells in Fuel Recovery Area H

Subsurface Fuel Thickness Measurements (ft)*											
Summary Sheet											
Well	11-Mar-88	20-Dec-90	29-May-91	31-Jul-92	7-Oct-92	4-Jan-93	28-May-93	7-Dec-93	7-Jan-94	28-Feb-94	2-May-94
RW-H1	0.77	0.27	N/A	3.50	0.07	3.96	3.45	3.26	3.32	N/A	N/A
RW-H2	0.54	0.30	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A
RW-H3	5.82	2.10	N/A	0.00	0.00	0.52	0.00	N/A	2.47	0.03	N/A
H-H1	2.97	2.40	1.96	2.26	2.74	2.84	2.32	N/A	Mud	2.04	2.10
GT-H1	3.58	2.75	2.80	0.00	1.13	1.53	2.23	3.61	3.56	0.61	N/A
GT-H2	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GT-H3	2.11	2.40	0.00	1.20	1.12	1.10	1.10	N/A	0.96	1.00	0.71
GT-H4	4.40	Gone	Gone	3.25	4.05	4.42	4.15	3.40	3.33	2.22	2.90
GT-H5	3.81	0.55	0.00	0.00	0.00	0.00	0.00	N/A	0.16	0.45	N/A
GT-H6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.00	N/A	N/A
GT-H7	0.00	Gone	Gone	0.00	0.00	0.00	0.00	N/A	0.00	N/A	N/A
GT-H8	3.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	N/A
GT-H9	4.31	Gone	N/A	N/A	N/A	N/A	N/A	3.70	3.51	2.61	3.60
GT-H10	3.59	4.60	3.65	Gone	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GT-H11	4.68	4.10	3.80	3.15	0.00	0.07	0.09	0.10	2.97	N/A	N/A
GT-H12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.00	N/A	N/A
GT-H13	2.56	3.00	0.00	2.38	2.89	2.93	2.95	N/A		2.62	N/A
GT-H14	1.67	2.00	0.05	0.41	0.95	0.95	0.95	N/A	0.00	N/A	N/A
GT-H15	0.00	0.00	Gone	N/A	N/A	N/A	N/A	N/A	Mud	N/A	N/A
GT-H16	3.74	3.15	2.60	0.00	0.00	3.08	2.90	N/A	2.59	N/A	N/A
GT-H17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.00	N/A	N/A
GT-H18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.00	N/A	N/A

Table 2. Subsurface Fuel Thickness for Wells in Fuel Recovery Area H (continued)

Subsurface Fuel Thickness Measurements (ft)*											
Summary Sheet											
Well	11-Mar-88	20-Dec-90	29-May-91	31-Jul-92	7-Oct-92	4-Jan-93	28-May-93	7-Dec-93	7-Jan-94	28-Feb-94	2-May-94
GT-H19	0.16	0.05	0.00	0.00	0.00	0.00	0.00	N/A	0.09	0.11	0.11
GT-H20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.00	N/A	N/A
GT-H21	0.00	0.00	Gone	Dry	N/A	N/A	N/A	N/A	Mud	N/A	N/A
GT-H22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.00	N/A	N/A
GT-H23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.00	N/A	N/A
GT-H24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.19	0.08	N/A
GT-H25	1.25	2.00	2.58	0.25	2.10	0.25	0.30	N/A	2.02	N/A	N/A

N/A = no measurement taken.
* = Based on the information provided, these data are assumed to be product thickness measurements.

Table 3. Subsurface Fuel Thickness for Various Wells Measured on December 7, 1993

Wells	Tank	Pump	Top of Fuel (ft in)	Bottom of Fuel (ft in)	Total[(a)] (ft in)
RW-G1	X	X	15'6.5"	18'9.5"	3'3"
GT-G3		X	15'7"	18'9"	3'2"
GT-G4		X	16'2"	-0-	-0-
GT-G9		X	13'5.5"	13'7"	1.5"
RW-G3	X	X	16'1"	-0-	-0-
GT-8		X	12'3.5"	15'1"	2'7.5"
GT-10		X	14'6"	17'9"	3'3"
GT-12		X	14'1.5"	17'6"	3'4.5"
RW-H1	X		17'1"	20'4"	3'3"
GT-H2			15'5"	19'1.5"	3'6.5"
GT-H4			15'5"	18'9"	3'4"
H-H8			9'4.5"	-0-	-0-
GT-H9			15'7"	19'4"	3'7"
RW-H2	X	X	18'8"	-0-	-0-
GT-H11		X	15'2.5"	15'3.5"	1"

(a) Measurements calculated in tenths of a foot.

Project Activities

The following field activities are planned for the bioslurper pilot test at Hickam AFB. Additional details about the activities are presented in the Test Plan and Technical Protocol for Bioslurping. Table 4 shows the schedule of activities for the Bioslurper Initiative at Hickam AFB.

1. Mobilization to the Site

When the site-specific test plan has been approved, Battelle staff will mobilize equipment to the test site All equipment will be shipped via Air Express to Hickam AFB prior to staff arrival. The Base Point of Contact (POC) will have been asked in advance to find a suitable holding facility to receive the bioslurper pilot test equipment, so that the equipment will be easily accessible to the Battelle staff when they arrive. Battelle personnel will be mobilized to the site after it has been confirmed that all equipment has been received by Hickam AFB. The Battelle POC will provide the Air Force POC with personal information for each Battelle employee who will be on site. The exact mobilization date will be confirmed with the Base POC as far in advance of fieldwork as is possible.

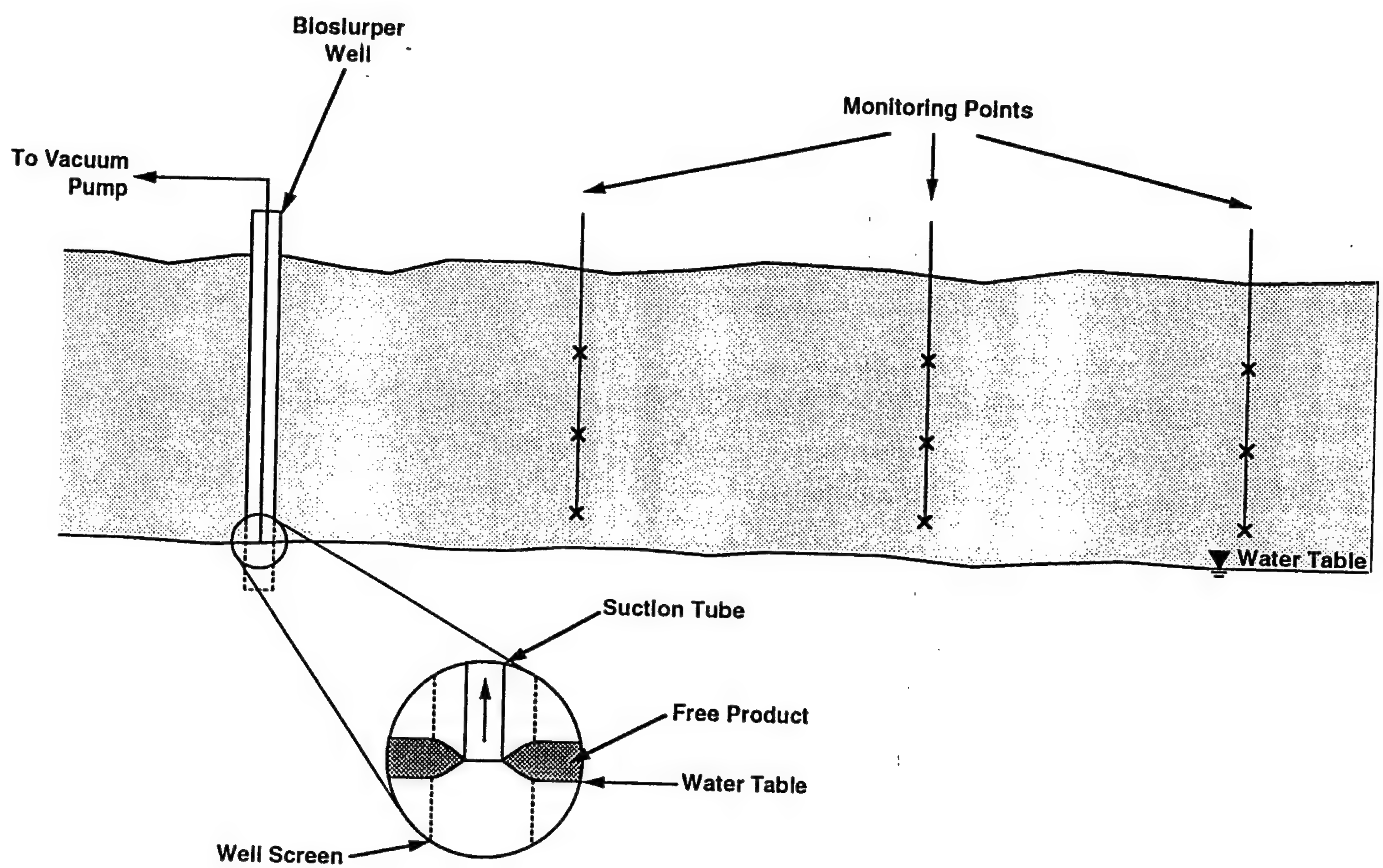


Figure 2. General Bioslurper Well and Monitoring Point Arrangement.

Table 4. Schedule of Bioslurper Test Activities

Pilot Test Activity	Schedule
Test Plan Approval	day (to be determined)
Mobilization	day 1-2
Site Characterization	day 2-3
Baildown Tests	
Soil Gas Survey (limited)	
Monitoring Point Installation (3 MPs)	
Soil Sampling	
System Installation	day 2-3
Test Startup	day 3
Skimmer Test (2 days)	day 3-4
Bioslurper Pump Test (4 days)	day 5-9
Air Permeability Testing	day 5
Simmer Test (continued)	day 10
Drawdown Pump Test (2 days)	day 11-12
In Situ Respiration Test (air/helium injection)	day 11
In Situ Respiration Test (monitoring)	day 11-16
Demobilization/Mobilization	day 13-14

2. Site Characterization Tests

2.1 *Soil Gas Survey (Limited)*

A small-scale soil gas survey will be conducted to identify the ideal location for the installation of the bioslurping system. The soil gas survey will be conducted in areas where historical site data indicate the highest contamination levels. In Tables 1 and 2, the heavily contaminated wells appear in bold type. The area around these wells will be surveyed to select the locations for installation of soil gas monitoring points. Soil gas monitoring point placement will be concentrated around areas that exhibit the following characteristics.

1. Soil vapor from the site will exhibit high TPH concentrations (10,000 ppm or greater).

2. Soil vapor will contain relatively low oxygen concentrations (between 0% and 2%).

3. Soil vapor will have relatively high carbon dioxide concentrations (depending on soil type, between 2% and 10% or greater).

To obtain further information about the soil gas survey, consult Section 5.2 of the Test Plan and Technical Protocol for Bioslurping.

2.2 *Baildown Tests*

The baildown test is used to determine the apparent amount of free product thickness located at the candidate well. Baildown tests will be performed at wells that contain measurable light, nonaqueous-phase liquid (LNAPL) thicknesses to estimate the LNAPL recovery potential at those particular wells. Detailed procedures for the baildown tests are provided in Section 5.6 of the Test Plan and Technical Protocol for Bioslurping.

2.3 *Monitoring Point Installations*

Monitoring point installation is necessary to determine the radius of influence that the free product recovery system has on aerating contaminated soils. Upon the conclusion of the initial soil gas survey, baildown tests, and slug tests, at least three soil gas monitoring points will be installed. These monitoring points should be located in highly contaminated soils within the free-phase plume, and should be positioned to allow detailed monitoring of the in situ changes in soil gas composition caused by the bioslurper system. The components of soil gas monitoring points are shown in Figure 3. A conceptual arrangement for soil gas monitoring points at Fuel Recovery Area H, Well No. GT-H9 is indicated in Figure 4. Information on monitoring point installation can be found in Section 4.2.1 of the Test Plan and Technical Protocol for Bioslurping.

2.4 *Soil Sampling*

Soil sampling will be done to determine the extent of contamination that the subsurface soils have been exposed to. Soil samples from the chosen site will be collected from boreholes advanced for monitoring point installation. Soil samples will be collected at two or three points in each area being characterized. At each point, samples will be collected from the surface and from about 3-foot-depth intervals. The final depth intervals will be selected to ensure that the vertical contaminant profile is adequately characterized in both the vadose zone and the capillary fringe over the free-phase plume.

Soil samples will be analyzed for particle size distribution; bulk density; porosity; moisture content; benzene, toluene, ethylbenzene, and xylenes (BTEX); and TPH. Section 5.5.1 of the Test Plan and Technical Protocol for Bioslurping will be consulted for information on the field measurements and sample collection procedures for soil sampling.

3. Bioslurper System Installation and Operation

Once the well to be used for the bioslurper test installation at Hickam AFB has been identified (most likely Well No. GT-H9), the bioslurper and support equipment will be installed and operated.

3.1 *System Setup*

All the previously shipped equipment will be mobilized from the holding facility to the test site, and the bioslurper system will be assembled. Figure 5 shows a flow diagram of the bioslurper process. Figure 6 is a generic diagram of the bioslurper extraction well that will be installed at Hickam AFB.

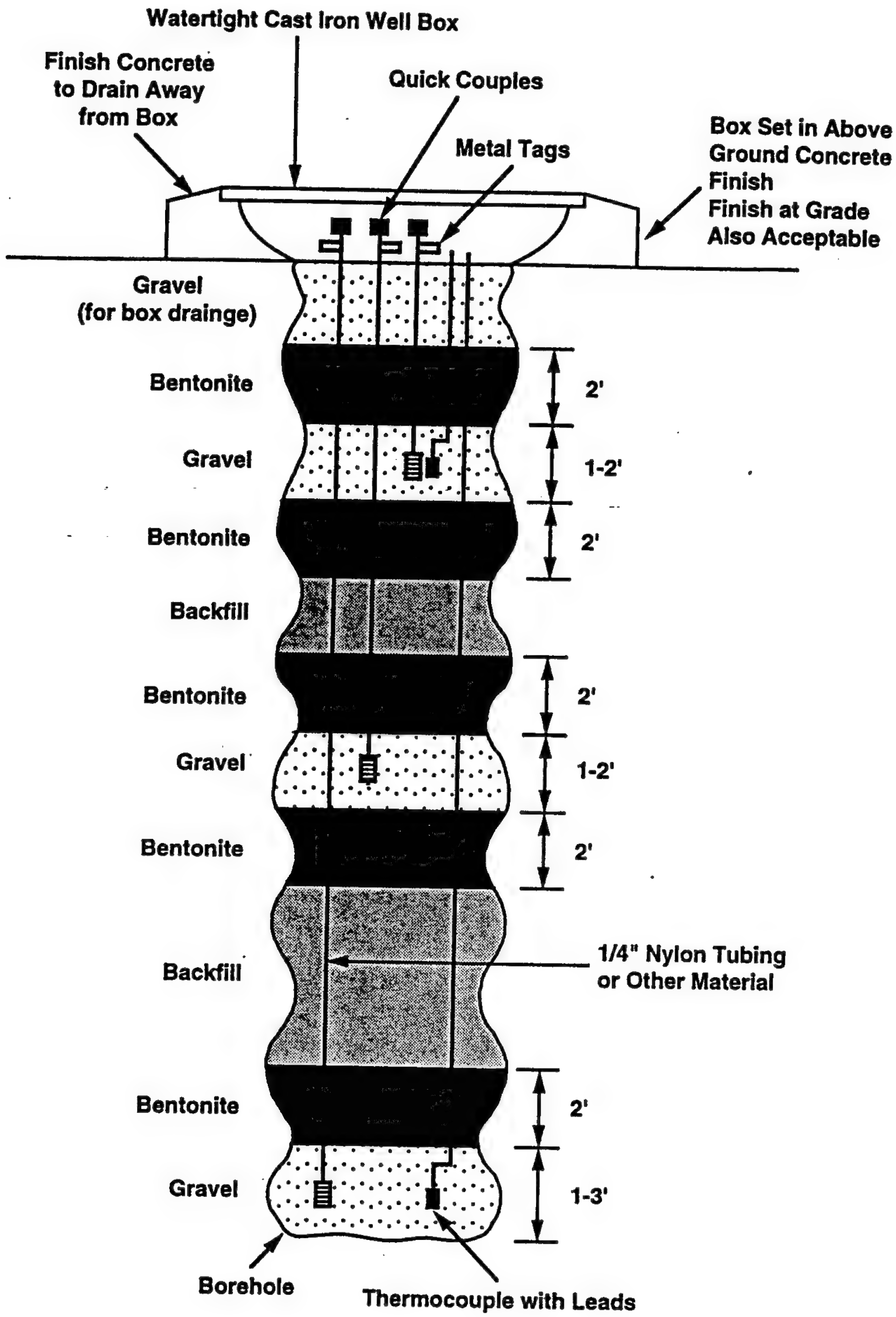


Figure 3. Diagram of a Typical Bioslurper Soil Gas Monitoring Point.

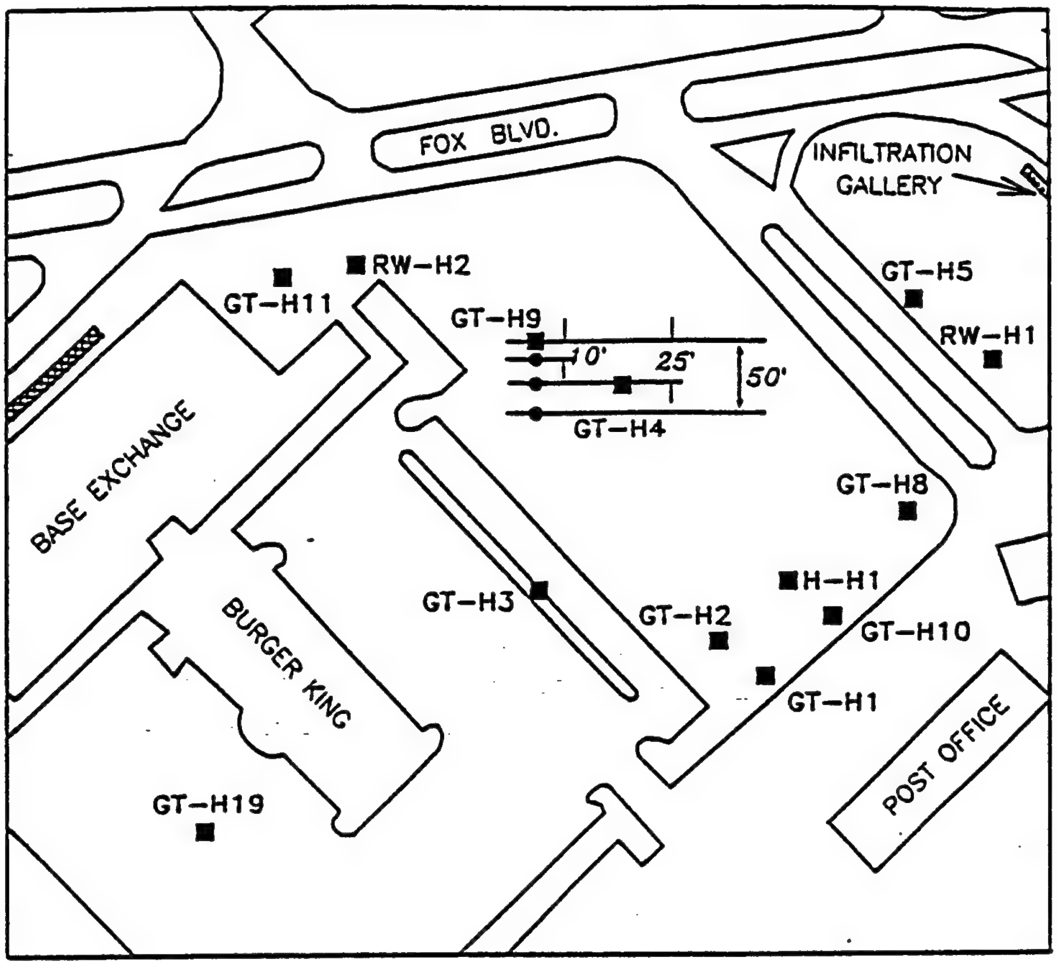


Figure 4. Conceptual Arrangement of Bioslurper Soil Gas Monitoring Points for Hickam AFB Fuel Recovery Area H.

Prior to the initiation of the LNAPL recovery tests, all the relevant baseline field data will be collected and recorded. These data will include soil gas concentrations, initial soil gas pressures, the depth to groundwater, and the LNAPL thickness. Also, ambient soil and all the atmospheric conditions (weather conditions, temperature, humidity, barometric pressure, etc.) will be recorded. All emergency equipment (i.e., emergency shutoff switches and fire extinguishers) will be installed and checked for proper operation at this time.

Well No. GT-H9 most likely will be used for the installation of the bioslurper extraction well. A clear level area near Well No. GT-H9 must be identified for the 20-ft by 10-ft area that will be needed to house the 3-hp pump and all other equipment required for the bioslurper system operation. For more information on the bioslurper system installation, consult Section 6.0 of the Test Plan and Technical Protocol for Bioslurping.

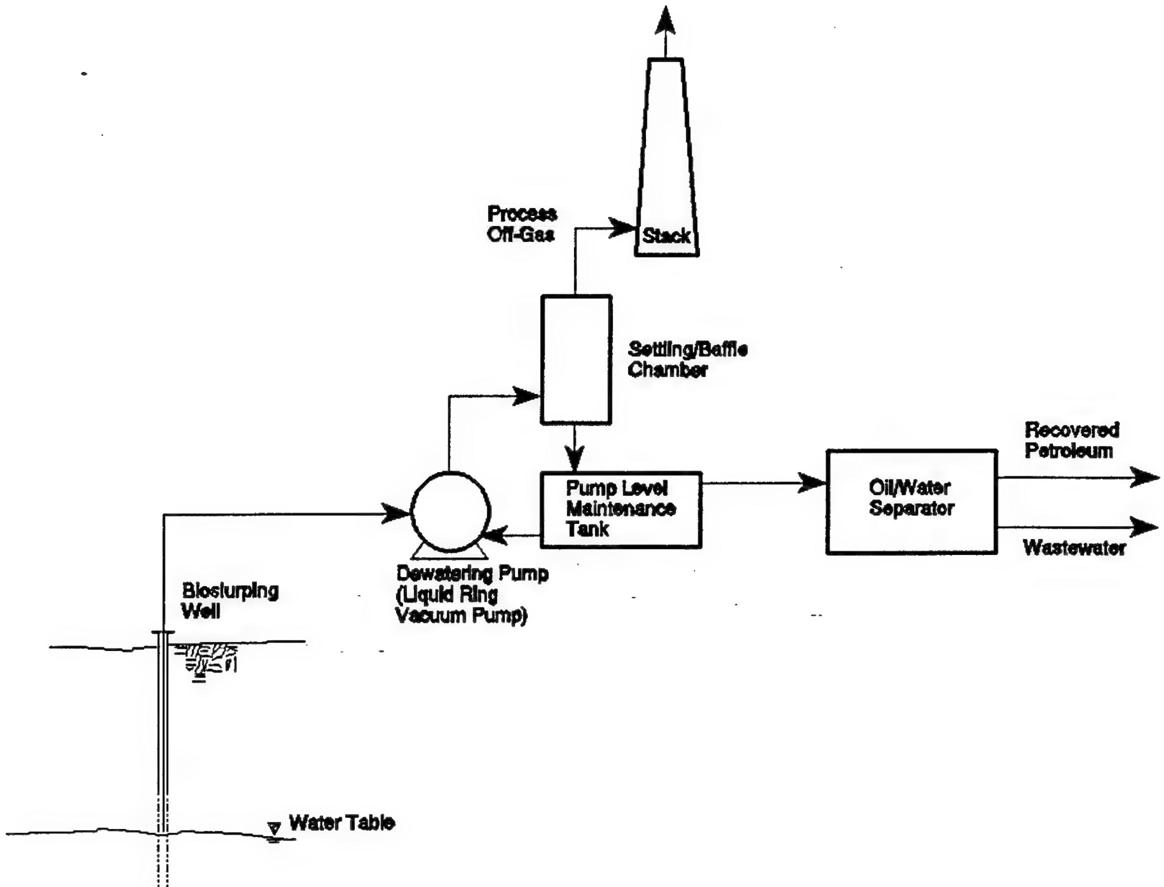


Figure 5. Bioslurper Process Flow.

3.2 *System Shakedown*

A brief startup test will be conducted to ensure that the system is properly constructed and operates safely. All system components will be checked for problems and/or malfunctions. A checklist will be provided to document the system shakedown.

3.3 *System Startup and Test Operations*

After installation is complete and the bioslurper system is confirmed to be operating properly, the LNAPL recovery tests will be started. The Bioslurper Initiative has been designed to evaluate the effectiveness of bioslurping as a LNAPL recovery technology relative to conventional gravity-driven LNAPL recovery technologies. The Bioslurper Initiative includes three separate LNAPL recovery tests: (1) a skimmer simulation test; (2) a vacuum-assisted bioslurper test; and (3) a groundwater drawdown LNAPL recovery test. The three recovery tests are described in detail in Section 7.3 of the Test Plan and Technical Protocol for Bioslurping.

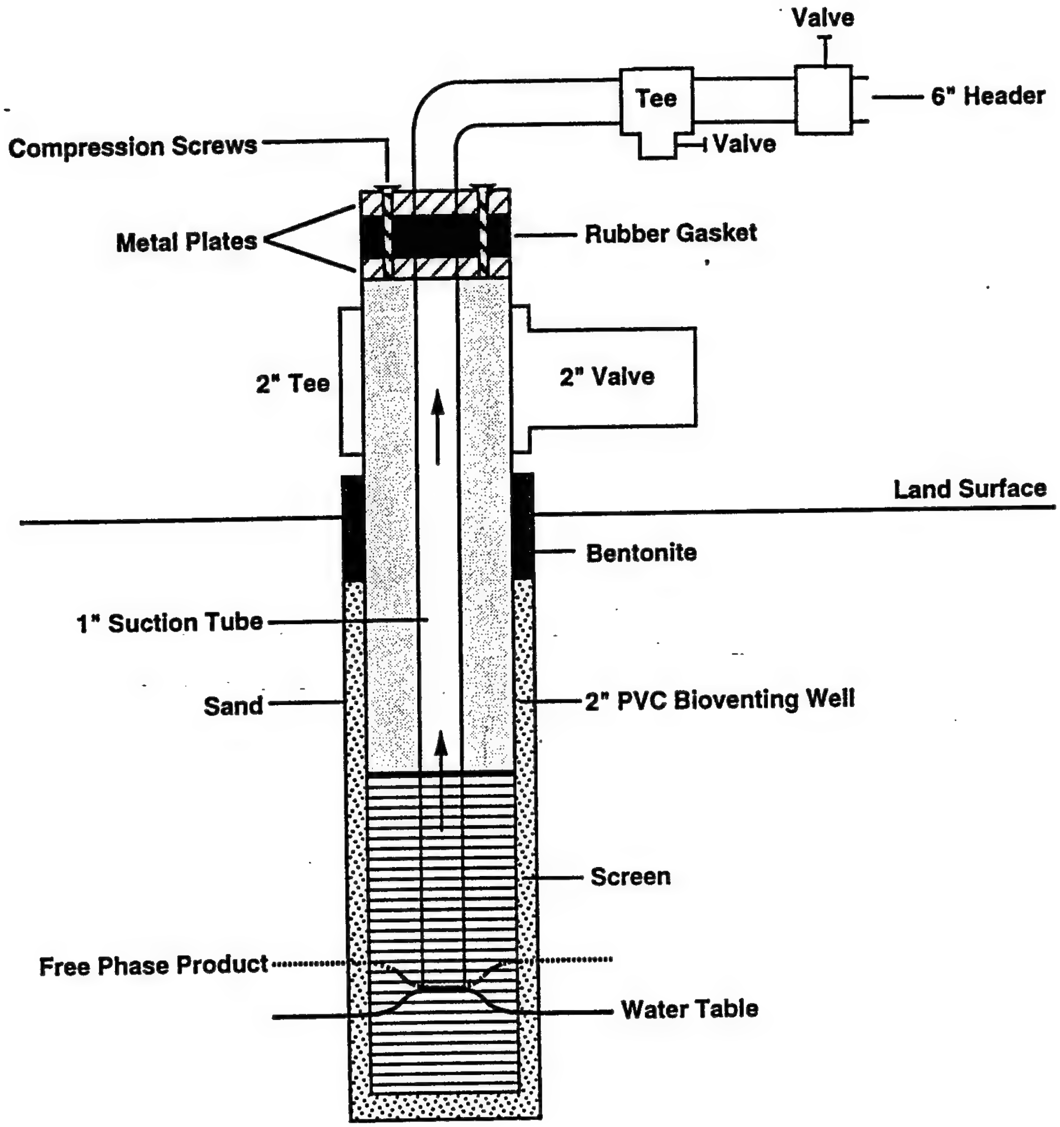


Figure 6. Diagram of a Typical Bioslurper Well.

Bioslurper operating parameters measured during operation are vapor discharge analysis, aqueous effluent analysis, LNAPL recovery volume rates, vapor discharge volume rates, and groundwater discharge volume rates. Vapor monitoring will consist of continuous on-line monitoring of TPH supplemented by two samples collected for detailed laboratory analysis. A total of two samples of aqueous effluent will be collected for analysis of BTEX and TPH content. Recovered LNAPL volume will recorded using an in-line flow-totalizing meter. The off-gas discharge volume will be measured using a calibrated pitot tube, and groundwater discharge volume will recorded using an in-line flow-totalizing meter. Section 8.0 of the Test Plan and Technical Protocol for Bioslurping describes the process monitoring of the bioslurper system.

3.4 *Soil Gas Permeability Tests*

A soil gas permeability test will be conducted concurrently with startup of the vacuum-assisted bioslurper operation. Soil gas permeability data support the process of estimating the vadose zone radius of influence of the bioslurper system. Soil gas permeability results also help in determining the number of wells required if it decided to treat the site with a large-scale bioslurper system. The soil gas permeability test method is described in Section 5.7 of the Test Plan and Technical Protocol for Bioslurping.

3.5 *In Situ Respiration Tests*

The rate of oxygen utilization will be used to estimate the biodegradation rate for the site. An in situ respiration test will be conducted after completion of the bioslurper operating tests. The in situ respiration testing will consist of air/helium injection into selected soil gas monitoring points followed by monitoring changes in concentration of oxygen, carbon dioxide, petroleum hydrocarbons, and helium in soil gas near the injection point. Measurement of the soil gas composition typically will be conducted at 2, 4, 6, and 8 hours and then every 4 to 12 hours for about 2 days. Timing of the tests will be adjusted based on oxygen use rate. If oxygen depletion occurs rapidly, more frequent monitoring will be required. If oxygen depletion is slow, less frequent readings will be acceptable. Further information on the procedures and data collection for in situ respiration testing is given in Section 5.8 of the Test Plan and Technical Protocol for Bioslurping.

3.6 *Extended Testing*

The Air Force has the option of extending the operation of the bioslurper system for up to 6 months if LNAPL recovery rates are promising. If extended testing is to be performed, additional site support will be required. The Air Force will need to provide electrical power for long-term operation of the bioslurper pump. Disposition of all generated wastes and routine operation and maintenance of the system will be the Air Force's responsibility. Battelle will provide technical support during the extended testing operation.

4. Demobilization

Once all the necessary tests have been completed at the Hickam AFB site, all the equipment will be disassembled by Battelle staff. The equipment will then be moved back to the holding facility where it will remain until it is determined what site it will be mobilized to next. Battelle staff will receive this information prior to leaving the site and will be responsible for the shipment of the equipment to the next site before they leave the site.

Bioslurper System Discharge

1. Vapor Discharge Disposition

Battelle expects that the operation of the bioslurper test system at the Hickam AFB site will require a waiver or a point source air release registration, and may require some additional permits. However, due to the short duration of the bioslurper pilot test and the 3-hp size pump that will be used, it can be assumed that the concentration of hydrocarbons (approximately 6.5 mg TPH/L) released to the atmosphere will not exceed 15 lb/day. The organic vapor discharge concentration was estimated

based on soil gas data collected during a bioventing study performed at Area H during the past year and a half. The organic vapor discharge rate should remain relatively constant throughout the pilot test. The vapor stream generated by the bioslurper system can be discharged directly to the atmosphere because of the short duration of the test and the low concentration levels of TPH and benzene in the stream.

To ensure the safety and compliability of the bioslurper system, vapor discharge samples (TPH, O_2, and CO_2) will be collected periodically throughout the bioslurper pilot test. Also, field soil gas screening instruments will be used to monitor vapor discharge concentration variability. The volume of vapor discharge will be monitored daily using air flow instruments. If state regulatory requirements will not permit the expected amount of organic vapor discharge to the atmosphere, the Base POC should inform AFCEE and Battelle so that alternative plans can be made prior to mobilization to the site. Table 5 presents information typically required to complete an air release registration form.

Table 5. Air Release Summary Information

Data Item	Air Release Information
Contractor Point of Contact	Jeff Kittel, (614) 424-6122
Contractor address	Battelle 505 King Avenue Columbus, Ohio 43201-2693
Estimated total quantity of petroleum product to be recovered	TBD
Description of petroleum product to be recovered	Diesel (JP-4 jet fuel)
Planned date of test start	TBD
Test duration	5 days (active pumping)
Maximum expected VOC concentration in air	<20 lb/day (18 lb TPH/day, <2 lb benzene/day)
Maximum total quantity of VOC release	<20 lb/day
Expected contaminants in air release	TPH, benzene (0.002 mg/L)
Expected quantity of fuel use (for electrical generator)	125 gallons
Type of fuel used	Gasoline and diesel fuel
Stack height above ground level	10 ft

2. Aqueous Influent/Effluent Disposition

The flowrate of groundwater pumped by the bioslurper will be less than 5 gpm. However, in Hawaii it may be necessary to obtain a groundwater pumping waiver or registration permit. If one is required, the base POC will inform Battelle of the necessary steps in obtaining the waiver or permit.

The operation of the bioslurper system will generate an aqueous waste discharge that will be passed through an oil/water separator. The intention of Battelle staff will be to dispose of the wastewater by discharge directly to the Base wastewater treatment facility. If existing Base wastewater channels can be used, no National Pollutant Discharge Elimination System (NPDES) or other water discharge permits will be required.

3. Free-Product Recovery Disposition

The bioslurper system will recover free-phase product from the pilot tests performed at Hickam AFB. Free product recovered by the bioslurping tests will be turned over to the Base for disposal and/or recycling. The volume of free product recovered from the Base will not be known until the tests have been performed. The maximum recovery rate for this system is 5 gpm. However, the actual rate of LNAPL recovery will be much lower.

Schedule

The schedule for the bioslurper fieldwork at Hickam AFB will depend on approval of the project test plans. Battelle will determine a definitive schedule as soon as possible after approval. Battelle will have two to three staff members on site for approximately 2 weeks to conduct all the necessary pilot testing. At the conclusion of the field testing at Hickam AFB, all staff will return their Base passes. Battelle staff will remove all bioslurper field testing equipment from the Base before they leave the site.

Project Support Roles

This section outlines the some of the major functions of personnel from Battelle, Hickam AFB, and AFCEE during the bioslurper field test.

1. Battelle Activities

The obligations of Battelle in the Bioslurper Initiative at Hickam AFB will be to supply all the necessary staff and equipment to perform all the tests on the bioslurper system. Also Battelle will provide technical support in the areas of water and vapor discharge permitting, digging permits, staff support during the extended testing period, and any other technical areas that need to be addressed.

2. Hickam AFB Support Activities

To conduct the necessary field tests at Hickam AFB, the Base must be able to provide the following items:

a. Any and all digging permits and utility clearances that need to be obtained prior to the initiation of the fieldwork. Any underground utilities should be clearly marked to reduce the chance of utility damage and/or personal injury during soil gas probe and well installation (if needed). Battelle will not begin field operations without these clearances and permits.

b. The Air Force will be responsible for obtaining Base and site clearance for the Battelle staff that will be working at the Base. The Base POC will be furnished with all the pertinent personal information for each staff member at least 1 week prior to field startup.

c. Access to the local sanitary sewer must be furnished, so that staff can discharge the bioslurper aqueous effluent directly to the Base treatment facility.

d. Regulatory approval, if any is required, will need to be obtained by the Base POC prior to startup of the bioslurper pilot test. As stated previously, it is likely that a waiver to allow air releases or a point source air release registration will be required for emissions of approximately 20 lb/day of benzene in a concentration of 0.015 mg benzene/L and total petroleum hydrocarbons (TPH) in a concentration of 6.5 mg TPH/L. A waiver for pumping groundwater at a rate of 5 gpm, and a water discharge permit or waiver for benzene and TPH in the same concentration levels in the wastewater at a rate of 5 gpm, might be required. The TPH and benzene concentration levels are the maximum levels of those components that would be released to the atmosphere. The Base POC will obtain all the necessary Base permits prior to mobilization to the site. Battelle will provide technical assistance in preparation of regulatory approval documents.

e. The Base also will be responsible for the disposition of all waste generated from the pilot testing. Such waste includes any soil cuttings generated from drilling, and all aqueous wastestreams produced from the bioslurper tests. Also, all free product recovered from the bioslurper operation will be disposed of or recycled by the Base. Battelle will provide technical assistance in disposing of the waste generated from the bioslurper pilot test.

f. The Health and Safety Plan for Hickam AFB will be finalized with information provided by the Base POC prior to field activities commencing. Table 6 is a checklist for the necessary information required to complete the Health and Safety Plan.

3. AFCEE Activities

The Air Force Center for Environmental Excellence (AFCEE) POC will act as a liaison between Battelle and Hickam Base staff. The AFCEE POC will ensure that all necessary permits are obtained and the required space to house the bioslurper field equipment is found. The following is a listing of Battelle, AFCEE, and Hickam Base staff that can be contacted in cases of emergency and/or required technical support during the bioslurper field initiative tests at Hickam AFB:

Battelle POCs	—	Jeff Kittel	614-424-6122
		Eric Drescher	614-424-3088
AFCEE POC	—	Patrick Haas	210-536-4314
Hickam AFB POC	—	Leanne Tanouye	808-449-9073

Regulator POCs	Air:	Tyler Sugihara	808-586-4200
	Water:	PWC Dennis Chang	808-471-7735
Facility POCs		(Fort Kameamea)	

Table 6. Health and Safety Information Checklist

The following emergency information will be obtained by the Site Health and Safety Officer prior to beginning operations:

Emergency Contacts	Name	Telephone No.
Hospital Emergency Room:	______________	______________
Point of Contact:	______________	______________
Fire Department:	______________	______________
Emergency Unit (Ambulance):	______________	______________
Security:	______________	______________
Explosives Unit:	______________	______________
Community Emergency Response Coordinator:	______________	______________
Other:	______________	______________

Program Contacts

Air Force: ______________________________

Battelle: ______________________________

Other: ______________________________

Emergency Routes

Hospital (maps attached): ______________________________

____

Other: ______________________________

APPENDIX B

ANALYTICAL DATA REPORTS

E.L. Pacific
Environmental Laboratory of the Pacific

A Full Service Laboratory for the Environmental Professional
930 Mapunapuna Street, Suite 100 • Honolulu, Hawaii 96819
Telephone: (808) 833-5663 Facsimile: (808) 833-7399

Laboratory Report

Client: Battelle
505 King Ave.
Columbus, OH 43201
Attention: Greg Headington

ELP Project No.: 2477
Report Date: 29-Mar-95

Client Job No.: G462201
Sample Description: Samples from Hickam AFB Bioslurping

Date Collected: 10-Mar-95
Date Received: 14-Mar-95

				Client ID:		MPA-13.0-13.6	D-2	D-1
				Date Collected:		10-Mar-95	10-Mar-95	10-Mar-95
				Matrix:		soil	soil	soil
				Lab ID:	Method Blank	031495-16	031495-18	031495-19
Date	**Analysis**	**Method**	**Units**	**MRL**	**Results**	**Results**	**Results**	**Results**
	BTEX in soil							
27-Mar-95	Extraction	EPA 5030						
27-Mar-95	Benzene	EPA 8020	mg/Kg (ppm)	0.005	ND	ND	ND	ND
27-Mar-95	Toluene	EPA 8020	mg/Kg (ppm)	0.005	ND	ND	**0.010**	ND
27-Mar-95	Ethylbenzene	EPA 8020	mg/Kg (ppm)	0.005	ND	**0.007**	**0.005**	ND
27-Mar-95	Xylenes	EPA 8020	mg/Kg (ppm)	0.010	ND	**0.021**	**0.018**	ND
	Surrogate (% Recovery)							
27-Mar-95	Trifluorotoluene				**80**	**78**	**75**	**77**
	TPH in soil							
27-Mar-95	Extraction	EPA 5030						
27-Mar-95	Gasoline	EPA 8015M	mg/Kg (ppm)	5	ND	ND	ND	ND

Approved by: Carol C Bratt for
Jeffrey Bryson, Laboratory Manager 3/29/95

E.L. Pacific

ELP Project No.: **2477**
Report Date: 29-Mar-95

					Client ID:		D-1	D-2
					Date Collected:		10-Mar-95	10-Mar-95
					Matrix:		soil	soil
					Lab ID:	Method Blank	031495-17	031495-18
Date	**Analysis**	**Method**	**Units**	**MRL**	**Regulatory Level ¤**	**Results**	**Results**	**Results**
	TCLP Metals in the extract							
16-Mar-95	TCLP Extraction	EPA 1311						
21-Mar-95	Metals Digestion	EPA 3010						
23-Mar-95	Cadmium	EPA 6010	mg/L (ppm)	0.05	1.0	ND	ND	ND
23-Mar-95	Chromium	EPA 6010	mg/L (ppm)	0.05	5.0	ND	ND	ND
23-Mar-95	Lead	EPA 6010	mg/L (ppm)	0.2	5.0	ND	ND	ND
	PAH in soil							
17-Mar-95	Extraction	EPA 3550						
21-Mar-95	Naphthalene	EPA 8270	mg/Kg (ppm)	50		ND	ND	ND
21-Mar-95	Acenaphthene	EPA 8270	mg/Kg (ppm)	50		ND	ND	ND
21-Mar-95	Fluoranthene	EPA 8270	mg/Kg (ppm)	250		ND	ND	ND
21-Mar-95	Benzo(a)pyrene	EPA 8270	mg/Kg (ppm)	1.0		ND	ND	ND
	Surrogate (% Recovery)							
21-Mar-95	Nitrobenzene-d5					79	72	88
21-Mar-95	2-Fluorobiphenyl					78	72	84
21-Mar-95	Terphenyl-d14					111	94	126

¤ Code of Federal Regulations, 40 CFR Part 261.24, Table 1

Approved by: Carol C Bratt 3/29/95 for
Jeffrey Bryson, Laboratory Manager

E.L. Pacific

ELP Project No.: 2477

Report Date: 29-Mar-95

				Client ID:			HIC-1-Eff
				Date Collected:			12-Mar-95
				Matrix:			water
				Lab ID:	Method Blank		031495-21
Date	**Analysis**	**Method**	**Units**	**MRL**	**Results**	**MRL**	**Results**
	BTEX in water						
21-Mar-95	Extraction	EPA 5030					
21-Mar-95	Benzene	EPA 8020	mg/L (ppm)	0.001	ND	0.005	**4.24**
21-Mar-95	Toluene	EPA 8020	mg/L (ppm)	0.001	ND	0.005	**0.102**
21-Mar-95	Ethylbenzene	EPA 8020	mg/L (ppm)	0.001	ND	0.005	**0.754**
21-Mar-95	Xylenes	EPA 8020	mg/L (ppm)	0.002	ND	0.010	**1.437**
	Surrogate (% Recovery)						
21-Mar-95	Trifluorotoluene				**93**		**123**
	TPH in water						
21-Mar-95	Extraction	EPA 5030					
21-Mar-95	Gasoline	EPA 8015M	mg/L (ppm)	1	ND		**32**

				Client ID:		HIC-2-Eff	HIC-Fuel
				Date Collected:		12-Mar-95	12-Mar-95
				Matrix:		water	water
				Lab ID:	Method Blank	031495-22	031495-20
Date	**Analysis**	**Method**	**Units**	**MRL**	**Results**	**Results**	**Results**
	BTEX in water						
21-Mar-95	Extraction	EPA 5030					
21-Mar-95	Benzene	EPA 8020	mg/L (ppm)	0.001	ND	**4.28**	NA*
21-Mar-95	Toluene	EPA 8020	mg/L (ppm)	0.001	ND	**0.202**	NA*
21-Mar-95	Ethylbenzene	EPA 8020	mg/L (ppm)	0.001	ND	**1.700**	NA*
21-Mar-95	Xylenes	EPA 8020	mg/L (ppm)	0.002	ND	**2.780**	NA*
	Surrogate (% Recovery)						
21-Mar-95	Trifluorotoluene				**93**	**153**	NA*
	TPH in water						
21-Mar-95	Extraction	EPA 5030					
21-Mar-95	Gasoline	EPA 8015M	mg/L (ppm)	1	ND	**232**	*NR*

* Comment: Sample 031495-20 could not be analyzed by EPA Method 8020. It is a pure product.

Approved by: Carl C. Bratt for

Jeffrey Bryson, Laboratory Manager 3/29/95

Quality Control Data

SPIKES		Lab ID: Units:	LCS1 %R	LCS2 %R	RPD	MS %R	MSD %R	RPD
Lab ID	**Analysis**	**Method**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
	BTEX in soil							
031795-06	Benzene	EPA 8020	83	NA	NA	70	65	7
031795-06	Toluene	EPA 8020	79	NA	NA	60	60	0
031795-06	Ethylbenzene	EPA 8020	82	NA	NA	63	70	11
031795-06	Xylenes	EPA 8020	82	NA	NA	65	59	10
	Surrogate (% Recovery)							
031795-06	Trifluorotoluene		77	NA	NA	61	46	28
	TPH in soil							
031795-06	Gasoline	EPA 8015M	109	NA	NA	¤	NA	NA
	TCLP Metals in the extract							
031595-14	Cadmium	EPA 6010	84	84	0	84	85	1
031595-14	Chromium	EPA 6010	86	88	2	88	97	10
031595-14	Lead	EPA 6010	83	81	2	¤	¤	¤
	PAH in soil							
031595-32	Acenaphthene	EPA 8270	74	73	1	82	79	4
031595-32	Pyrene	EPA 8270	102	106	4	113	111	2
	Surrogate (% Recovery)							
031595-32	Nitrobenzene-d5		87	83	5	91	87	4
031595-32	2-Fluorobiphenyl		87	82	6	91	88	3
031595-32	Terphenyl-d14		111	111	0	117	120	3
	BTEX in water							
031495-25	Benzene	EPA 8020	99	98	1	90	98	9
031495-25	Toluene	EPA 8020	99	97	2	93	99	6
031495-25	Ethylbenzene	EPA 8020	99	98	1	93	100	7
031495-25	Xylenes	EPA 8020	100	98	2	94	100	6
	Surrogate (% Recovery)							
031495-25	Trifluorotoluene		93	93	0	90	96	6
	TPH in water							
031495-25	Gasoline	EPA 8015M	104	NA	NA	101	NA	NA

¤ native analyte greater than 4 times the spike added, therefore recovery not calculable

Approved by: Carl C Bralts for
Jeffrey Bryson, Laboratory Manager
3/29/95

Definitions

D	Duplicate
LCS	Laboratory Control Sample
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MRL	Method Reporting Limit
NA	Not Applicable
ND	Not Detected at the MRL
NR	Not Requested
OS	Original Sample
%R	Percent Recovery
PDS	Post Digestion Spike
RPD	Relative Percent Difference

Approved by: Carl C. Bratti for

Jeffrey Bryson, Laboratory Manager 3/29/95

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. 0314-16→22

Proj. No. G462201

Project Title: Hickam AFB Bioslurping

SAMPLERS: (Signature) Jon Eastep / Greg Headington (614) 424-5417

ELP #: 2477
Rpt d/d: 28-MAR
Lab d/d: 24-MAR
Container: Liner/tin Baggie
Location: #11/#6

DATE	TIME	SAMPLE I.D.	BTEX/TPH	Particle Size	Bulk Density	Porosity	Moisture Content	PAH	TCLP, Pb, Cd, Chrom	BTEX		Container No.	Number of Containers	Remarks
3-10-95		# MPA-13.0-13.6	X	X	X	X					0314 95-16		1	2½x6" Sleeve
3-10-95		# D-1						X	X		-17		1	poly bag
3-10-95		# D-2	X					X	X		-18		1	poly bag
3-10-95		# D-1	X								-19		1	2"x6" Sleeve
3-12-95		Hic-Fuel								X	-20		1	Vial/AVGAS
3-12-95		Hic-1-Eff	X								-21		2	40cc vials
3-12-95		Hic-2-Eff	X								-22		2	40cc vials

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Greg Headington	13 MAR 95 10 AM	Bill [illegible]	[illegible] E Lucazon	3/14/95 11:35	
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	

@ AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 9503123

Work Order Summary

CLIENT:	Mr. Al Pollack Battelle 505 King Ave. Columbus, OH 43201	**BILL TO:**	Ms. Amanda Bush Battelle 505 King Ave. Columbus, OH 43201
PHONE:	614-424-3753	**INVOICE #**	6347
FAX:	614-424-3667	**P.O. #**	91221
DATE RECEIVED:	3/14/95	**PROJECT #**	G462201 Hickam AFB
DATE COMPLETED:	3/21/95	**AMOUNT$:**	$605.07

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.	PRICE
01A	Stack-2-MCBH	TO-3	0.5 "Hg	$125.00
02A	MCBH-Stack-1***	TO-3	0 "Hg	$125.00
03A	Hick-1	TO-3	0.4 psi	$125.00
04A	Hick-2	TO-3	0 "Hg	$125.00
05A	Lab Blank	TO-3	NA	NC
05B	Lab Blank	TO-3	NA	NC

Misc. Charges	1 Liter SUMMA Canister Preparation (4) @ $10.00 each.	$40.00
	Shipping (2/15/95)	$65.07

LAB NARRATIVE:

***Sample received out of hold time; analyzed per client's request.

CERTIFIED BY: Robert Freeman

Laboratory Director

DATE: 3/21/95

180 BLUE RAVINE ROAD, SUITE B FOLSOM, CA 95630
(916) 985-1000 • (800) 985-5955 • FAX (916) 985-1020

AIR TOXICS LTD.

SAMPLE NAME: Stack-2-MCBH
ID#: 9503123-01A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6031514		Date of Collection: 3/2/95	
Dil. Factor:	25		Date of Analysis: 3/15/95	

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.025	0.081	Not Detected	Not Detected
Toluene	0.025	0.096	Not Detected	Not Detected
Ethyl Benzene	0.025	0.11	2.2	9.7
Total Xylenes	0.025	0.11	2.0	8.8

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	6031514		Date of Collection: 3/2/95	
Dil. Factor:	25		Date of Analysis: 3/15/95	

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	0.25	1.6	1700	11000
C2 - C4** Hydrocarbons	0.25	0.46	0.65	1.2

*TPH referenced to Jet Fuel (MW=156)

**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: MCBH-Stack-1***
ID#: 9503123-02A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6031606		Date of Collection: 2/25/95	
Dil. Factor:	25		Date of Analysis: 3/16/95	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
Benzene	0.025	0.081	Not Detected	Not Detected
Toluene	0.025	0.096	Not Detected	Not Detected
Ethyl Benzene	0.025	0.11	3.9	17
Total Xylenes	0.025	0.11	4.2	18

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	6031606		Date of Collection: 2/25/95	
Dil. Factor:	25		Date of Analysis: 3/16/95	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
TPH* (C5+ Hydrocarbons)	0.25	1.6	2300	15000
C2 - C4** Hydrocarbons	0.25	0.46	0.89	1.6

*TPH referenced to Jet Fuel (MW=156)
**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: Hick-1
ID#: 9503123-03A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6031515	Date of Collection: 3/12/95
Dil. Factor:	24000	Date of Analysis: 3/15/95

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	24	78	Not Detected	Not Detected
Toluene	24	92	Not Detected	Not Detected
Ethyl Benzene	24	110	95	420
Total Xylenes	24	110	100	440

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Gasoline)

File Name:	6031515	Date of Collection: 3/12/95
Dil. Factor:	24000	Date of Analysis: 3/15/95

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	240	1000	100000	420000
C2 - C4** Hydrocarbons	240	440	760	1400

*TPH referenced to Gasoline (MW=100)

**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: Hick-2
ID#: 9503123-04A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6031517		Date of Collection: 3/12/95	
Dil. Factor:	84		Date of Analysis: 3/15/95	

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.084	0.27	Not Detected	Not Detected
Toluene	0.084	0.32	Not Detected	Not Detected
Ethyl Benzene	0.084	0.37	0.18	0.79
Total Xylenes	0.084	0.37	0.28	1.2

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Gasoline)

File Name:	6031518		Date of Collection: 3/12/95	
Dil. Factor:	50		Date of Analysis: 3/15/95	

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	0.50	2.1	26	110
C2 - C4** Hydrocarbons	0.50	0.91	0.85	1.6

*TPH referenced to Gasoline (MW=100)

**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank
ID#: 9503123-05A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6031504		Date of Collection: NA	
Dil. Factor:	1.0		Date of Analysis: 3/15/95	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
Benzene	0.001	0.003	Not Detected	Not Detected
Toluene	0.001	0.004	Not Detected	Not Detected
Ethyl Benzene	0.001	0.004	Not Detected	Not Detected
Total Xylenes	0.001	0.004	Not Detected	Not Detected

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Gasoline)

File Name:	6031504		Date of Collection: NA	
Dil. Factor:	1.0		Date of Analysis: 3/15/95	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
TPH* (C5+ Hydrocarbons)	0.010	0.042	Not Detected	Not Detected
C2 - C4** Hydrocarbons	0.010	0.018	Not Detected	Not Detected

*TPH referenced to Gasoline (MW=100)
**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: NA

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank
ID#: 9503123-05B

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6031605		Date of Collection: NA	
Dil. Factor:	1.0		Date of Analysis: 3/16/95	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
Benzene	0.001	0.003	Not Detected	Not Detected
Toluene	0.001	0.004	Not Detected	Not Detected
Ethyl Benzene	0.001	0.004	Not Detected	Not Detected
Total Xylenes	0.001	0.004	Not Detected	Not Detected

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Gasoline)

File Name:	6031605		Date of Collection: NA	
Dil. Factor:	1.0		Date of Analysis: 3/16/95	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
TPH* (C5+ Hydrocarbons)	0.010	0.042	Not Detected	Not Detected
C2 - C4** Hydrocarbons	0.010	0.018	Not Detected	Not Detected

*TPH referenced to Gasoline (MW=100)
**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: NA

Battelle
Columbus Laboratories

9503123

Form No. ____

CHAIN OF CUSTODY RECORD

Proj. No. 6462201

Project Title Hickam AFB
Kaneohe MCBH

SAMPLERS: (Signature) Jon Eastep / Greg Headington (614)424-5417

	DATE	TIME	SAMPLE I.D.	BTEX/TPH	Container No.	Number of Containers	CAN # Remarks
01A	02 MAR 95		Stack-2-MCBH	X	0.5"Hg		12373
02A	25 FEB ~~02 MAR~~ 95		MCBH-Stack-1	X	0"Hg		12370
03A	12 MAR 95		Hick-1-~~Stack~~	X	0.4"Hg		14517
04A	12 MAR 95		Hick 2-	X	0"Hg		11445

Rec'd KB

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Greg Headington	13MAR95				

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)

Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks
		[signature]	3/14/95 10:15	Air Toxics

HICK SAMPLES ARE > 100,000 ppm - 11.c-1
5c -H Z
HICK SAMPLES ARE
... GAS VAPOR ...

Page ____ of ____

ADVANCED TERRA TESTING, inc.

833 Parfet Street
Lakewood, Colorado 80215
(303) 232-8308

MECHANICAL ANALYSIS - SIEVE TEST DATA

CLIENT	E.L. Pacific	JOB NO.	2216-02
BORING NO.	JN2477	SAMPLED	3-10-95 GH
DEPTH	13.0-13.5	DATE TESTED	4-4-95 REW
SAMPLE NO.	031495-16	WASH SIEVE	Yes
SOIL DESCR.		DRY SIEVE	No

MOISTURE DATA

HYGROSCOPIC	Yes
NATURAL	No

Wt. Wet Soil & Pan	(g)	57.79
Wt. Dry Soil & Pan	(g)	54.13
Wt. Lost Moisture	(g)	3.66
Wt. of Pan Only	(g)	3.71
Wt. of Dry Soil	(g)	50.42
Moisture Content	%	7.3

Wt. Hydrom. Sample Wet (g)	55.23
Wt. Hydrom. Sample Dry (g)	51.49

WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	62.01
Weight of + #10 Before Washing (g)	6.78
Weight of + #10 After Washing (g)	6.06
Weight of - #10 Wet (g)	55.23
Weight of - #10 Dry (g)	52.16
Wt. Total Sample Dry (g)	58.22
Calc. Wt. "W" (g)	57.47
Calc. Mass + #10	5.98

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	0.00	0.00	0.00	0.0	100.0
3/8"	0.00	2.29	2.29	2.29	3.9	96.1
#4	0.00	1.55	1.55	3.84	6.6	93.4
#10	0.00	2.22	2.22	6.06	10.4	89.6
#20	1.30	6.55	5.25	5.25	19.5	80.5
#40	1.56	7.68	6.12	11.37	30.2	69.8
#60	1.58	5.98	4.40	15.77	37.8	62.2
#100	1.32	4.99	3.67	19.44	44.2	55.8
#200	1.58	6.36	4.78	24.22	52.5	47.5

ADVANCED TERRA TESTING, INC.

HYDROMETER ANALYSIS - SEDIMENTATION DATA

CLIENT	E.L. Pacific	JOB NO.	2216-02
BORING NO.	JN2477	SAMPLED	3-10-95 GH
DEPTH	13.0-13.5	DATE TESTED	4-4-95 REW
SAMPLE NO.	031495-16	WASH SIEVE	Yes
SOIL DESCR.		DRY SIEVE	No

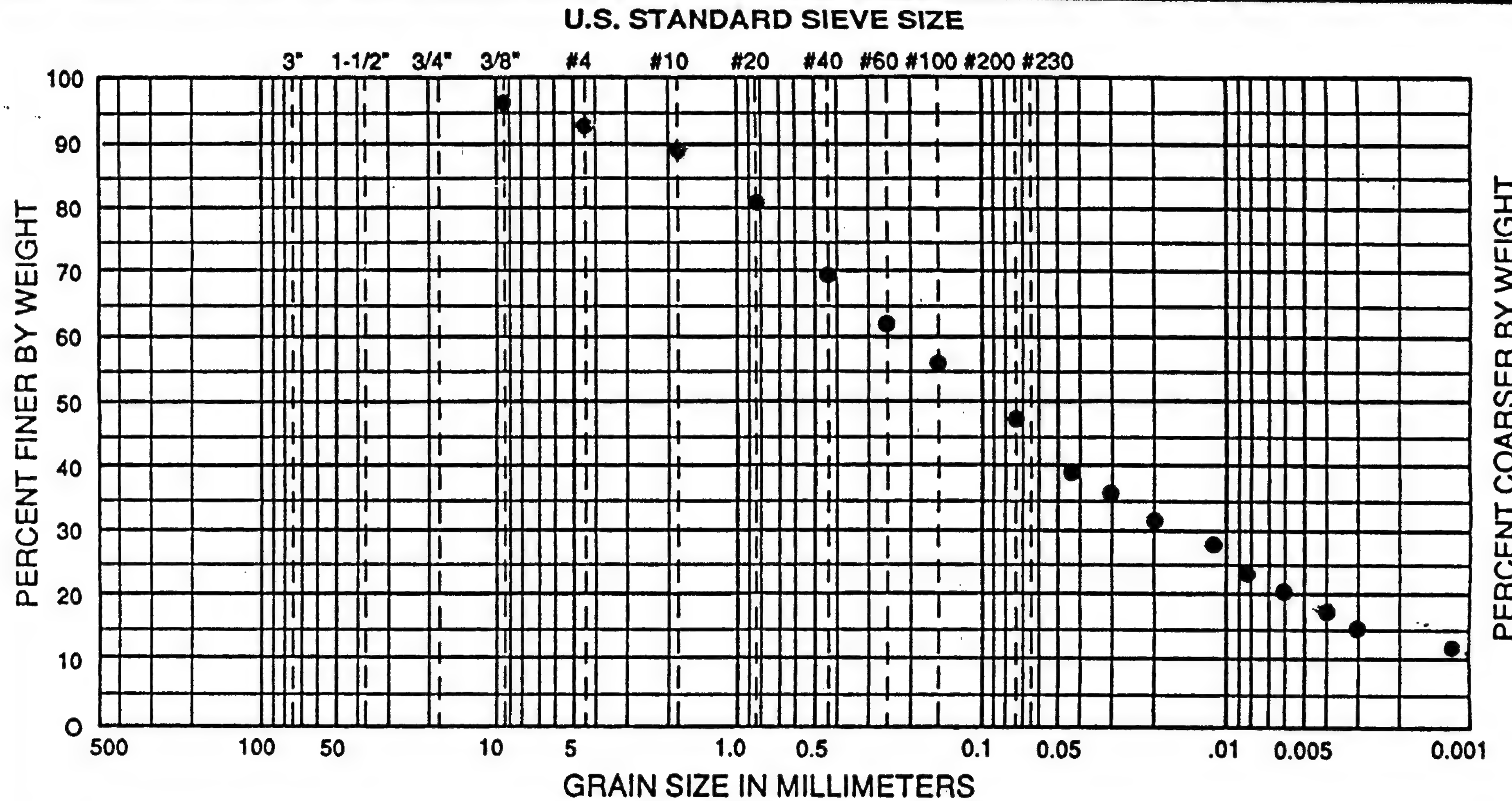
Hydrometer #	ASTM 152 H	Temp., Deg. C	23.9
Sp. Gr. of Soil	2.74	Temp. Coef. K	0.01270
Value of "a"	0.98	Wt. Dry Sample "W"	57.474
Deflocculant	Sodium Hexametaphosphate	% of Total Sample	100.0
Defloc. Corr'n	4.0		
Meniscus Corr'n	-1.0		

T Elapsed Time (min)	Hydrometer Reading Original	Corrected "R"	100Ra/W	% Total Sample	Effective Depth L	Grain Diameter (mm)
0.0	--	--	--	--	--	--
0.5	29.00	24.00	41.0	41.0	11.53	0.0610
1.0	28.00	23.00	39.3	39.3	11.70	0.0434
2.0	26.00	21.00	35.9	35.9	12.03	0.0311
5.0	23.50	18.50	31.6	31.6	12.44	0.0200
15.0	21.50	16.50	28.2	28.2	12.76	0.0117
30.0	19.50	14.50	24.8	24.8	13.09	0.0084
60.0	17.00	12.00	20.5	20.5	13.50	0.0060
120.0	15.50	10.50	17.9	17.9	13.75	0.0043
250.0	14.00	9.00	15.4	15.4	13.99	0.0030
1325.0	11.50	6.50	11.1	11.1	14.40	0.0013

Grain Diameter = K*(SQRT(L/T))

ADVANCED TERRA TESTING, INC.

ADVANCED TERRA TESTING



USCS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE	

WENTWORTH	COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY
		COARSE	MED	FINE	GRAN	COARSE	MED	FINE		

WELLNAME: ______ SAMPLE NO.: 031495-16 DATE: ______ PROJECT NO.: ______

AREA	DEPTH	CLASSIFICATION

SPECIFIC GRAVITY
ASTM D 854

ADVANCED TERRA TESTING inc

Page ____ of ____

Specific Gravity Tests

Client E.L. Pacific

Job No. 2216-02 Location

Boring No.	13.0-13.5 3N 2477
Sample No.	031495-16
Sampled	
By:	
Tested	4-4-95
By:	KEW
Checked	4-05-95
By:	cal
Specific Gravity Flask #	2
Weight of flask (g)	
Weight of oven dry soil (g) (Wo)	25.127
Weight of flask, soil and water (g) (Wb)	177.988
Temperature (deg. C) (Tx)	24.0
Weight of water & flask at Tx (from cal. curve) (Wa)	162.042
Specific Gravity *	2.74
Pan No.	14 BB

* Specific Gravity = Wo/[Wo+(Wa−Wb)]

ADVANCED TERRA TESTING, inc.
833 Parfet Street
Lakewood, Colorado 80215
(303) 232-8308
Fax: (303) 232-1579

MOISTURE & DENSITY
ASTM D 2216 & ASTM D 2937

MOISTURE AND DENSITY DETERMINATIONS

ADVANCED TERRA TESTING ...

CLIENT El. Pacific JOB NO. 2216-02

LOCATION Hickam MPA-13-13-13.5 JN 2477

SAMPLE & SOIL TYPE	BORING	MPA
	SAMPLE NO.	031495-K
	SAMPLE DEPTH	13.0-13.5'
	DATE SAMPLED BY	3-10-95 GH
	DATE TESTED BY	3-27-95 DSL
	SOIL TYPE	
	POROSITY	.5791
DENSITY	NO. OF RINGS	H_o = 4.711 D_o = 2.430
	WT. OF WET SOIL & RINGS	799.28
	WT. OF RINGS	235.95
	WT. OF WET SOIL	563.33
	WET DENSITY (LBS./CU.FT.)	98.2
	DRY DENSITY (LBS./CU.FT.)	72.0
MOISTURE CONTENT	DISH NO.	35 ~~[illegible]~~
	WT. OF WET SOIL & DISH	282.57 ~~[illegible]~~ DL
	WT. OF DRY SOIL & DISH	209.42
	NET LOSS OF MOISTURE	73.15
	WT. OF DISH	8.36
	WT. OF DRY SOIL	201.06
	MOISTURE CONTENT (% DRY WT.)	36.4

Test by ________ Date ________

Checked by WEB Date 3-28-95

ADVANCED TERRA TESTING, inc.
833 Parfet Street
Lakewood, Colorado 80215
(303) 232-8308
Fax: (303) 232-1579

CHAIN-OF-CUSTODY RECORDS

ENVIRONMENTAL [redacted]
930[redacted]pu[redacted]na[redacted]Sui[redacted]
Honolulu, Hawaii 96819
Tel: (808) 833-5663 • Fax: (808) 833-7399

LAB JOB NO. ______
LAB DUE DATE ______
LOCATION ______

Chain of Custody / Analysis Request Form

Project Manager: Jeff Bryson

Name ______
Address ______
Phone ______ FAX ______

Project I.D. ______
Job Name ______
Job Number 2477
P.O. Number ______

3. Sampled by (Please Print) ______
4. # of Samples in Shipment: 1
5. Date of Sample Shipment ______
6. Date Results Needed: 3/31/95

Indicate Analysis Requested: Particle size; Bulk Density; Porosity

Item No.	Sample Number	Sample ID	COMP	GRAB	Matrix	Preservation Method	Sampling Date	Sampling Time	Number of Containers	Particle size	Bulk Density	Porosity	Laboratory Number
1		031495-16			Soil X		3/10/95		1	X	X	X	
2													
3													
4													
5													
6													
7													
8													
9													
10													

Lab ID ______

Released by (Signature)	Date / Time Released	Delivery Method	Received by (Signature)	Company / Agency Affiliation	Date / Time Received	Condition Noted
S Grace	3/22/95 /	FedExp			/	
S. GRACE	/				/	

Comments: Please fax results before mailing final
Refer to job # on invoice & report

Please Check Box
- ☐ Dispose by Lab
- ☐ Return to Client
- ☐ Archive

FILE COPY

APPENDIX C

SYSTEM CHECKLIST

Checklist for System Shakedown

Site: HICKAM AFB, HAWAII

Date: ____________

Operator's Initials: JE

Equipment	Check if Okay	Comments
Liquid Ring Pump	✓	
Aqueous Effluent Transfer Pump	✓	
Oil/Water Separator	✓	
Vapor Flowmeter	✓	
Fuel Flowmeter	✓	
Water Flowmeter	✓	
Emergency Shut off Float Switch	✓	
2 Effluent Transfer Tank	✓	
Analytical Field Instrumentation	✓	
GasTector™ O_2/CO_2 Analyzer	✓	
TraceTector™ Hydrocarbon Analyzer	✓	
Oil/Water Interface Probe	✓	
Magnehelic Boards	✓	
Thermocouple Thermometer	✓	

APPENDIX D

DATA SHEETS FROM THE SHORT-TERM PILOT TEST

Fuel and Water Recovery Data

Site: Hickam AFB **Start Date:** ____________

Test Type: Skimmer **Operaters:** ____________

Date/Time (mm/dd/yr hr:min)	Elapsed Time (hours)	LNAPL Recovery				Groundwater Recovery			
		Collected (gal)	Total (gal)	Rate (gpd)	Avg. Rate (gpd)	Collected (gal)	Total (gal)	Rate (gpd)	Avg. Rate (gpd)
3/10/95 9:45	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3/10/95 10:00	0	9.00	9.00	864.00	864.00	0	0.00	0.00	0.00
3/10/95 21:00	11	33.60	42.60	71.68	90.88	0	0.00	0.00	0.00
3/11/95 9:55	24	9.00	51.60	8.94	51.24	668.6	668.60	663.99	663.99
3/11/95 14:12	28	7.00	58.60	5.91	49.43	470	1138.60	396.49	960.51
3/11/95 22:30	37	5.70	64.30	3.72	41.99	0	1138.60	0.00	960.51
3/12/95 7:40	46	4.70	69.00	2.46	36.07	130	1268.60	67.95	663.08
Total Hours	45.92	Rate (GPH)	1.50	Rate (GPD)	36.07	Rate (GPH)	27.63	Rate (GPD)	663.08

Pumping Test Data

Site: Hickam AFB
Operators: G. Headington/J. Eastep
Test Type: Skimmer

Start Date: 10-Mar-95
Start Time: 9:45
Well ID: GT-H-9

Depth to GW (ft): 18.33
Depth to Tube (ft): 14.44
Depth to Fuel (ft): 16.44

Date/Time (mm/dd/yr hr:min)	Run Time (min.)	Vapor Extraction			Pump Stack Temp. (°C)	Pump Head Vacuum (in Hg)	Tank Temp. (°C)	Tank Press. (psi)	Stack TPH (ppm)	Stack 0_2 (%)	Stack CO_2 (%)
		Stack Pressure (in H_2O)	Carbon Drums (in H_2O)	Flow rate (scfm)							
3/10/95 9:45	0	0.0	0.0	-	35.0	23.0	-	-	20.0	-	-
3/10/95 10:00	15	0.0	0.0	-	35.0	23.0	-	-	30.0	-	-
3/10/95 10:35	50	-	-	-	35.0	23.5	-	-	-	-	-
3/10/95 18:00	495	-	-	-			-	-	-	-	-
3/10/95 19:30	585	0.0	0.0	-	35.6	23.0	-	-	-	-	-
3/10/95 22:00	735	-	-	-	-	-	-	-	-	-	-
3/10/95 22:45	780	-	-	-	-	-	-	-	-	-	-
3/11/95 6:00	1215	0.0	0.0	-	37.8	23.0	-	-	30.0	-	-
3/11/95 7:00	1275	0.0	0.0	-	28.3	25.0	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-
3/11/95 14:00	1695	0.0	0.0	-	54.6	22.5	-	-	30.0	-	-
3/11/95 21:00	2115	0.0	0.0	-	60.8	17.2	-	-	45.0	-	-
3/12/95 7:30	2745	0.0	0.0	-	49.7	21.1	-	-	-	-	-

Fuel and Water Recovery Data

Site: Hickam AFB **Start Date:** 3/12/95

Test Type: Vacuum Enhancement **Operaters:** G. Headington/J. Eastep

Date/Time (mm/dd/yr hr:min)	Elapsed Time (hours)	LNAPL Recovery				Groundwater Recovery			
		Collected (gal)	Total (gal)	Rate (gpd)	Avg. Rate (gpd)	Collected (gal)	Total (gal)	Rate (gpd)	Avg. Rate (gpd)
3/12/95 11:50	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3/12/95 15:14	3.4	6.83	6.83	48.21	48.21	200	200.00	1411.76	1411.76
3/12/95 17:21	5.5	14.00	20.83	61.09	90.89	330	530.00	1440.00	2312.73
Total Hours	89.00	Rate (GPH)	0.23	Rate (GPD)	5.62	Rate (GPH)	5.96	Rate (GPD)	142.92

Pumping Test Data

Site: Hickam AFB
Operators: G. Headington/ J. Eastep
Test Type: Vacuum Enhancement

Depth to GW (ft): 15.80
Depth to Tube (ft): 16.00

Depth to Fu

Date/Time (mm/dd/yr hr:min)	Run Time (min)	Vapor Extraction			Pump Stack Temp. (°C)	Pump Head Vacuum (in Hg)	Slurper Vacuum (in H_2O)	Tank Temp. (°C)
		Stack Pressure (in H_2O)	Carbon Drums (in H_2O)	Flow rate (scfm)				
3/12/95 11:50	0	-	-	-	-	23.0	-	-
3/12/95 15:50	240	0.5	-	3.20	37.0	20.0	0.7	-
3/12/95 17:21	331	0.5	-	3.20	37.0	20.0	0.7	-

Fuel and Water Recovery Data

Site: Hickam AFB **Start Date:** 3/14/95
Test Type: Drawdown **Operaters:** Headington/Eastep

Date/Time (mm/dd/yr hr:min)	Elapsed Time ~~(min)~~ hrs	LNAPL Recovery				Groundwater Recovery			
		Collected (gal)	Total (gal)	Rate (gpd)	Avg. Rate (gpd)	Collected (gal)	Total (gal)	Rate (gpd)	Avg. Rate (gpd)
3/14/95 9:40	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3/14/95 10:40	1	16.00	16.00	384.00	384.00	150	150.00	3600.00	3600.00
3/14/95 11:18	2	7.00	23.00	102.86	337.96	0	150.00	0.00	3600.00
3/14/95 11:39	2	10.50	33.50	127.06	405.38	0	150.00	0.00	3600.00
3/14/95 12:16	3	8.10	41.60	74.77	384.00	0	150.00	0.00	3600.00
3/14/95 14:40	5	43.50	85.10	208.80	408.48	740	890.00	3552.00	4272.00
Total Hours	5.00	Rate (GPH)	17.02	Rate (GPD)	408.48	Rate (GPH)	178.00	Rate (GPD)	4272.00

Pumping Test Data

Site: Hickam AFB
Operators: G. Headington/ J. Eastep
Test Type: Drawdown

Start
Start
W

Depth to GW (ft): ______
Depth to Tube (ft): Variable

Depth to Fuel (ft): ______

Date/Time (mm/dd/yr hr:min)	Run Time (min)	Vapor Extraction			Pump Stack Temp. (°C)	Pump Head Vacuum (in Hg)	Tank Temp. (°C)	Tank Press. (psi)	Stack TPH (ppm)
		Stack Pressure (in H_2O)	Carbon Drums (in H_2O)	Flow rate (scfm)					
3/14/95 9:40	0	nd	-		-	18.0	-	-	-
3/14/95 9:43	3	0.0	-	2.0	22.8	21.0	-	-	-
3/14/95 9:53	13	-	-	0.0	33.7	25.0	-	-	-
3/14/95 11:00	80	0.0	-	0.0	37.8	23.0	-	-	-
3/14/95 12:07	147	0.0	-	0.0	39.4	22.2	-	-	-
3/14/95 13:00	200	0.0	-	0.0	42.7	23.0	-	-	-
3/14/95 14:40	300	-	-	-	-	-	-	-	-

APPENDIX E

SOIL GAS PERMEABILITY TEST RESULTS

Table E-1. Results of Air Permeability Test at Monitoring Point MPA at Hickam AFB

Time (min)	Pressure ("H_2O) by Depth		
	8.0′	12.0′	15.0′
0	0.02	0.54	0.54
1	<0	0.30	0.30
2	<0	0.35	0.35
3	<0	0.35	0.35
4	<0	0.35	0.35
5	<0	0.37	0.36
6	<0	0.45	0.40
7	<0	0.45	0.45
8	<0	0.45	0.45
9	<0	0.45	0.45
10	<0	0.50	0.50
11	<0	0.47	0.47
12	<0	0.45	0.45
14	<0	0.45	0.45
16	<0	0.45	0.45
18	<0	0.45	0.45
20	<0	0.45	0.45
25	<0	0.34	0.34
28	<0	0.35	0.35
34	<0	0.35	0.35
47	<0	0.30	0.30
57	<0	0.34	0.34
75	<0	0.26	0.27
120	<0	0.26	0.26
157	<0	0.26	0.26
216	<0	0.26	0.26

Note: MPA, all points under pressure. Magnehelic Gauges were zeroed at 1.0 H_2O. Reading on this table must reach 1.0 H_2O in order to be at atmospheric pressure.

Table E-2. Results of Air Permeability Test at Monitoring Point MPB at Hickam AFB

Time (min)	Pressure ("H_2O) by Depth		
	8.0′	12.0′	15.0′
0	0.02	0	0.25
2	0	0.005	0.195
3	0	0	0.25
4	0	0	0.01
5	0	0	0
6	0	0	0.005
7	0	0	0.005
8	0	0	0.007
9	0	0	0.007
10	0	0	0.005
11	0	0	0.005
12	0	0	0.005
13	0	0	0.005
15	0	0	0.005
17	0	0	0.005
19	0	0	0.005
21	0	0	0.005
26	0	0	0.005
29	0	0	0.005
35	0	0	0.005
49	0	0	0.005
59	0	0	0.005
76	0	0	0.005
120	0	0	0.145
158	0	0	0.13
216	0	0	0.18

Note: MPB - 15.0 has a positive pressure unitl the five minute reading, then a negative pressure is observed.

Table E-3. Results of Air Permeability Test at Monitoring Point MPC at Hickam AFB

Time (min)	Pressure ("H_2O) by Depth		
	11.0′	**13.5′**	**16.5′**
2	0.0	pressure	pressure
4	0.0	0.45	0.80
6	0.4	0.65	0.75
10	1.0	0.65	1.40
12	0.165	0.65	0.75
14	0.05	0.65	1.45
24	0.005	0.50	1.35
28	0.003	0.62	1.48
36	0.0	0.50	1.50
54	0.005	0.40	1.50
56	0.008	0.52	1.50
70	0.01	0.33	1.54
120	0.01	0.24	1.54
157	0.005	0.25	1.60/0.05
216	0.015	0.24	1.47

Note: MPC - 13.5 and 16.5, Atmospheric pressure is equal to 1.5 H_2O on the magnehelic gauges at the initial reading, thus need to be greater than 1.5 H_2O to be a negative pressure.

APPENDIX F

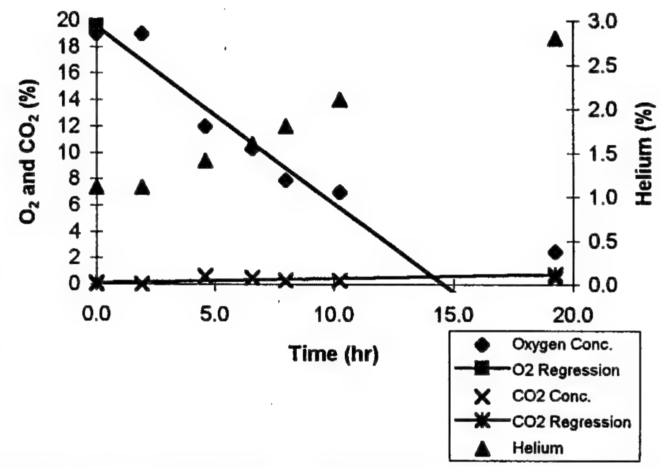
IN SITU RESPIRATION TEST RESULTS

Utilization Rates (3)

Date: 3/14/95 **Site Name:** Hickam AFB

Monitoring Point: MPC **Depth of M.P. (ft):** 13.5

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
3/14/95 14:45	0.0	19.00	0.00	1.10
3/14/95 16:40	1.9	19.00	0.00	1.10
3/14/95 19:21	4.6	12.00	0.60	1.40
3/14/95 21:20	6.6	10.30	0.50	1.60
3/14/95 22:44	8.0	7.90	0.30	1.80
3/15/95 1:00	10.2	7.00	0.30	2.10
3/15/95 10:00	19.2	2.50	0.50	2.80



O_2 Utilization Rate

Ko	0.022	%/min
	1.343	%/hr
	32.223	%/day

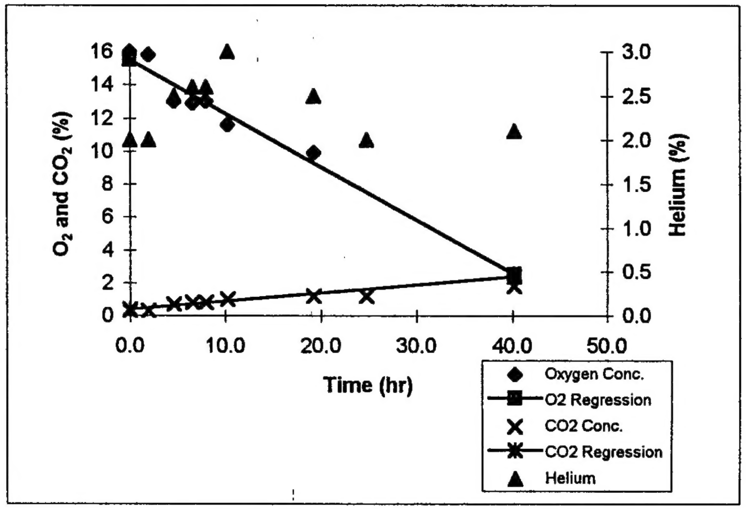
Regression Lines	O_2	CO_2
Slope	-1.3426	0.0360
Intercept	19.5448	0.0951
Determination Coef.	0.9377	0.3091
No. of Data Points.	6	6

Utilization Rates (1)

Date: 3/14/95 **Site Name:** Hickam AFB

Monitoring Point: MPA **Depth of M.P. (ft):** 12

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
3/14/95 14:45	0.0	16.00	0.30	2.00
3/14/95 16:40	1.9	15.80	0.30	2.00
3/14/95 19:21	4.6	13.00	0.70	2.50
3/14/95 21:20	6.6	12.90	0.80	2.60
3/14/95 22:44	8.0	13.00	0.80	2.60
3/15/95 1:00	10.2	11.60	1.00	3.00
3/15/95 10:00	19.2	9.90	1.20	2.50
3/15/95 15:30	24.8	10.00	1.20	2.00
3/16/95 7:00	40.2	8.70	1.80	2.10



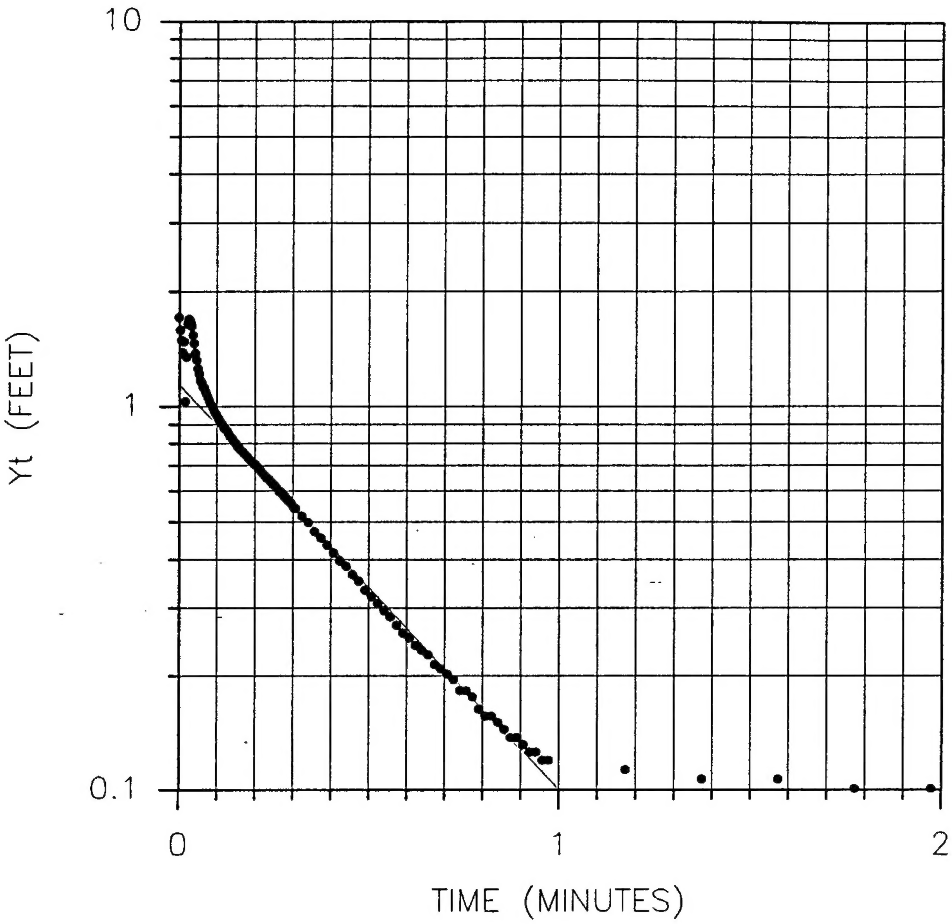
O_2 Utilization Rate

Ko	0.005 %/min
	0.322 %/hr
	7.734 %/day

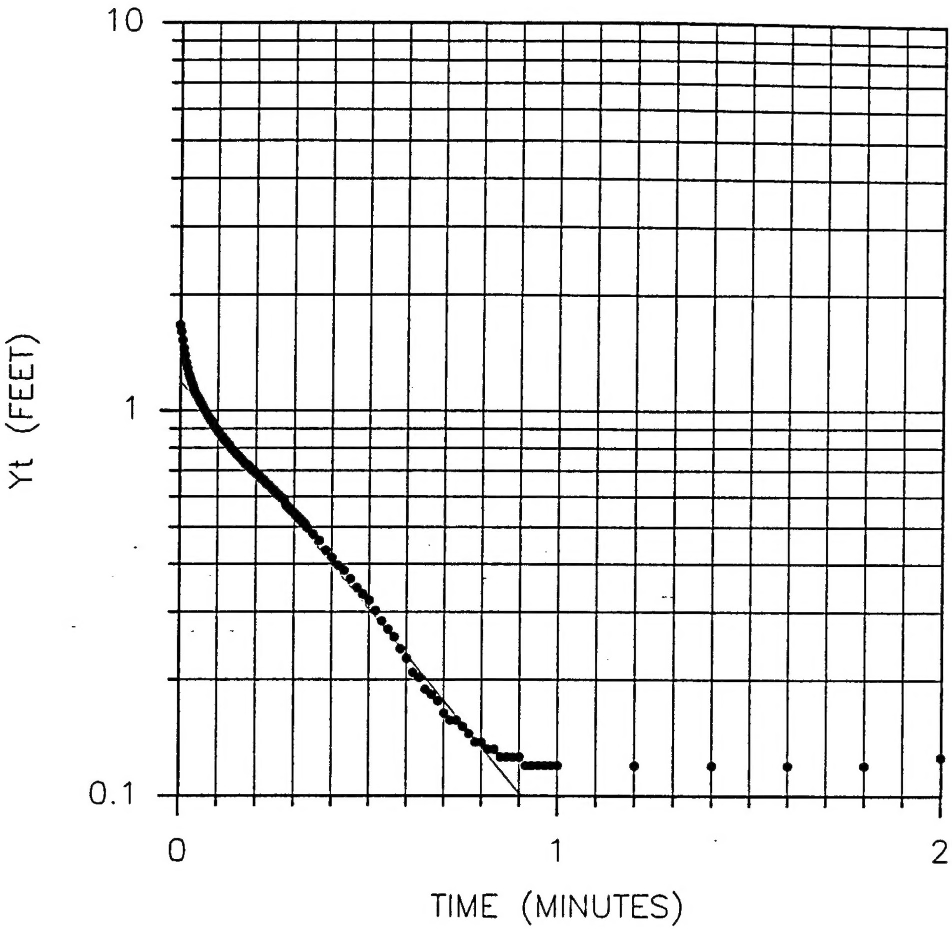
Regression Lines	O_2	CO_2
Slope	-0.3223	0.0494
Intercept	15.5001	0.3719
Determination Coef.	0.8908	0.8743
No. of Data Points.	7	7

APPENDIX G

SLUG TESTING RESULTS



Bouwer and Rice Slug Test Analysis						
Well Replicate #1						
D =	37	ft				
L =	18	ft				
H =	5.57	ft				
rw =	1	ft				
rc =	0.333	ft				
L/rw =	18.00			ln Re/rw =	1.18	
A =	2			Re =	3.25	
B =	0.5					
t =	1	min		K =	13.01	ft/day
Yt =	0.1	ft				
Yo =	1.2	ft				



Bouwer and Rice Slug Test Analysis						
Well GT-H9 Replicate #2						
D =	37	ft				
L =	18	ft				
H =	5.57	ft				
rw =	1	ft				
rc =	0.333	ft				
L/rw =	18.00			ln Re/rw =	1.18	
A =	2			Re =	3.25	
B =	0.5					
t =	0.5	min		K =	12.34	ft/day
Yt =	0.4	ft				
Yo =	1.3	ft				